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Cyclopedia
of
Motion-Picture Work

A General Reference Work on

THE OPTICAL LANTERN, MOTION HEAD, SPECIFIC PROJECTING MACHINES, TALKING PICTURES, COLOR MOTOGRAPHY, FIXED CAMERA PHOTOGRAPHY, MOTOGRAPHY, PHOTO-PLAYS, MOTION-PICTURE THEATER, MANAGEMENT AND OPERATION, AUDIENCE, PROGRAM, ETC.

Prepared by
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Illustrated with Over Three Hundred Engravings

TWO VOLUMES

CHICAGO
AMERICAN SCHOOL OF CORRESPONDENCE
1911

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Foreword

TWENTY years ago the motion picture was a child's toy. Today it is the basis of a business giving profitable employment to thousands of workers, offering amusement and education to millions of people, and involving an investment of capital that places it among the world's great industries.

¶ The motion-picture maker sets up his whirring camera in the wilds and the crowded city alike. He records the downfall of kings and the inauguration of presidents, the horrors of great disasters and the deeds of popular heroes; he spreads before us in moving panorama all that is interesting in nature and in man's work, in drama and in real life. Every large city has its motion-picture factory, and every village its motion-picture theater. Into communities too small to support a theater regularly comes the traveling exhibitor with his portable outfit, and shows in town hall, church, or country school house.

¶ For so important an industry a book of reference and instruction is more than merely justified; it is demanded. The motion-picture field is broadening day by day; the details of the business are becoming more multitudinous with each advance. The worker in one branch of activity must have some knowledge of all the branches to be able to get the best results in his own work. This Cyclopedia of Motion-Picture Work is the first compilation to cover adequately the entire field.

¶ The Art of the motion picture comprises two principal industries: the manufacturing, and the exhibiting, of film pictures. Both of these fields are covered by this Cyclopedia. The worker in either will be deeply interested in the detail and technique of the other, and will profit by that broader knowledge. The beginner requires a complete knowledge of both branches to fit himself for work in either branch.

¶ The drawings, diagrams, and photographs incorporated into the Cyclopedia have been prepared especially for this work; and their instructive value is as great as that of the text itself. They have been used to illustrate and expand the text, and not as a medium around which to build the text. Both drawings and diagrams have been rendered as simply as was compatible with their correctness, with a view to making them as nearly as possible self-explanatory.

¶ The Cyclopedia is a compilation of many of the most valuable Instruction Papers of the American School of Correspondence, and the method adopted in its preparation is that which this School has developed and employed so successfully for many years. This method is not an experiment, but has stood the severest of all tests—that of practical use—which has demonstrated it to be the best yet devised for the education of the busy man.

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JANE RETURNS TO THE CITY AFTER A WEEK'S VACATION
Scene from Photoplay, "The Snare of the City'
Courtesy of *Essanay Film Mfg. Co., Chicago*

THE OPTICAL LANTERN

INTRODUCTION

The optical lantern is a device for showing an enlarged reproduction of a small picture upon a screen before an audience. The small picture from which the projection is made is most conveniently a transparent picture, formed photographically upon glass by photographic processes. Modifications of the lantern may be made to show pictures upon opaque surfaces, such as newspaper clippings or souvenir postcards, or may show projections from solid objects. Still another modification of the optical lantern is that in which the motion head with its strip of pictures is substituted for the fixed slide in its carrier, and motion pictures are shown upon the screen.

The lantern consists primarily of a lamp for lighting the slide and a system of lenses for focusing the slide upon the distant picture screen. A slide holder is provided for receiving the slide and is adapted to hold it in position in the lens and lamp system. A lamp house is provided for the lamp, obscuring all light except that which passes from the lamp through the slide and through the lens system. The lens system usually is divided, one part being placed between the lamp and the slide, and the other part being placed between the slide and the picture screen upon which the image of the slide is to be projected. The lenses between the lamp and the slide are called the condensers, and the lenses between the slide and the picture screen are called the objective lenses, or more briefly, the lens.

THE ELEMENTS OF THE LANTERN

The parts going to make up the complete lantern system ready for projection may be listed as lamp, lamphouse, condenser, slide, slide holder, lens, and screen. The complete system of the lantern is shown in Fig. 1, which shows in diagram the elements arranged

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in their proper relation when in use. At *L* is shown an electric arc, in the lamphouse *LH.* In the front of the lamphouse is mounted the condenser *C,* consisting of two condenser lenses in a frame. In front of the condenser *C* is the slide holder *SH* and in it the slide *SL.* In front of the slide holder and its slide, and at a little distance, is the objective lens *O,* while at the extreme right is the picture screen *PS,* upon which the lens *O* concentrates in focus the light received from the lamp *L* through the condenser *C* and slide *SL.*

The Optical System. The light originates at *L,* and it is desired to get as much as possible of that light upon the screen *PS.* For that purpose, the system of lens glasses is used. Projection without lenses is possible, but not in any way practicable. To collect as much as possible of the light of the lamp *L,* a lens glass having a large surface is placed near the lamp. This is the back condenser lens, or left lens of the two in the condenser case at *C.* All the light falling upon the flat surface of the back condenser lens is bent into substantially straight lines, and thrown upon the curved surface of the front condenser lens. The front condenser bends the rays of light again and causes them to converge at the point of the focal center of the objective lens *O,* where they cross and proceed to the picture screen *PS.* The distribution of the light upon the picture screen by the condenser lenses and the objective lens, without a slide in the holder, is perfectly uniform when lamp and lenses are properly adjusted. When a picture slide *SL* is placed in the holder *SH,* some of the light is obstructed by the darker spots of the picture while nearly the full intensity of the light is permitted to pass through the transparent portions of the slide. The result is that the picture of

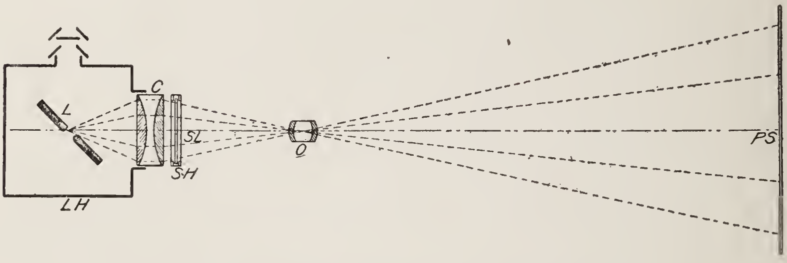


Fig. 1. Complete Optical System of the Lantern

the slide is transferred to the picture screen in the form of a shadow of the slide, and in much enlarged form. To secure a sharp image of the picture of the slide upon the screen *PS*, the slide *SL* must be exactly placed in the cone of light at the proper distance from the lens *O*. This distance is determined by the amount of curvature of the glasses of the lens, a dimension which is called the "focal length" of the lens. For a fixed slide of ordinary size, the lens is chosen of such focal length that the slide is properly placed nearly against the face of the condensers, as shown in the diagram. For microscopic projection a lens of very short focus is chosen and the slide is placed very near the lens, while for motion-picture projection a lens is chosen having about one-third the focal length of a lens for projecting fixed slides, and the motion-picture film is placed much nearer to the lens and much farther away from the condenser than is the slide *SL* in the diagram of Fig. 1. The length of the focus of the lens and the position of the slide being determined, the finer and final adjustment for causing the slide to be focused properly upon the picture screen is made by moving the lens itself slightly into an accurate position of focus.

The Inverted Slide. From Fig. 1 it can be seen that the ray of light which passes through the top of the slide *SL* ultimately reaches the bottom of the picture screen *PS*. Likewise, the ray of light passing through the bottom of the slide reaches the top of the picture screen, and all intermediate points are found upon the picture screen in their proper order and in inverted relation with reference to the position of the slide in the holder *SH*. In order to effect the projection of the picture upon the screen with the top of the picture at the top of the screen, the slide is inserted in the holder inverted.

Not only is the slide reversed top for bottom, but it is reversed also right for left. A square slide may be placed in the slide holder in eight different positions, only one of which is correct. The American standard slide, which is a little wider than it is high, still can be placed in the slide holder in four different positions, only one of which is correct. In strictly picture slides, it may be sufficient to get the bottom of the slide at the bottom of the screen, but where there are letters or words, such as signs, in the picture, or titles written or printed, it is necessary also to have the left side of the slide at the left side of the screen

Placing Slide in Holder. The simplest rule is the safest. *Take the slide in the left hand and look through it, holding it so that it is correct, top at top and left at left, holding it by the upper left-hand corner and viewing it as it is to be viewed upon the screen by the audience.* This position of the slide and of the left hand holding it is shown in Fig. 2. *Face the screen standing at the side of the lantern, and with the right hand take hold of the lower left-hand corner of the slide.* This position of the hands is shown in Fig. 3. *Now release the slide with the left hand and without changing the grip turn the hand with the slide, keeping the same side of the slide toward the eyes, so that the slide is held inverted* as shown in Fig. 4; *still facing the picture screen, drop the slide into the carrier and push the carrier into place in the slide holder.* In brief, *hold it so that it "reads right," catch it by the lower left-hand corner and drop it into the carrier.*

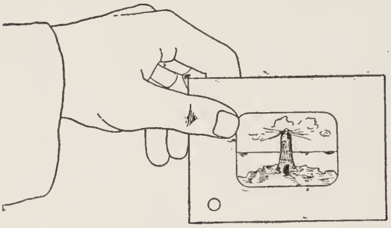
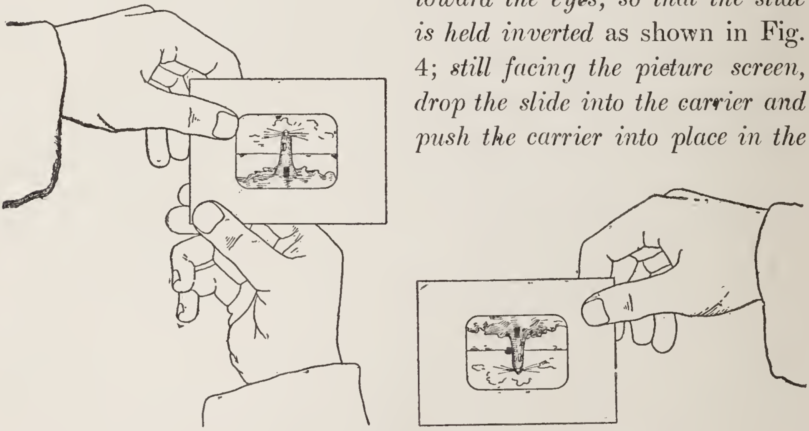


Fig. 2. Method of Holding and Turning the Slide for Proper Insertion Into the Lantern



Figs. 3 and 4. Method of Holding and Turning the Slide for Proper Insertion Into the Lantern

Thumb Spots. Finger marks on the face of the slide show plainly on the picture screen, and are very undesirable; the moral is to clean the slides before showing them the first time and then to keep them clean by handling them only by the edges or masked margins where finger marks if any will not show upon the picture screen. The "thumb spot," however, is a different matter. In Fig. 5, at the upper right-hand corner of the figure and, therefore, at the lower left-hand corner of the slide when viewed as in Fig. 2, is shown a small circle or spot. This is the thumb spot, and if the thumb of the right hand is placed upon this spot the slide will go into the carrier properly inverted and will appear in its proper position on the screen. Thumb spots may be bought, cut from gummed paper, as circles or stars, or may be clipped square from paper and gummed on. The advantage of the thumb spot gummed upon the outer surface of the glass is that it may be felt, and the lantern operator knows without looking at his slide that it is in the proper position and will appear correctly upon the screen. The disadvantage of the gummed thumb spot is that it sometimes comes off.

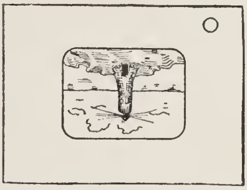


Fig. 5. Thumb Spot on the Lantern Slide

Another method of providing for the thumb spot is to paste it upon the mask, or upon the inside of the glass of the slide (some masks are printed with thumb spots upon them) but this has the disadvantage of requiring the operator to look at the slide to find the thumb spot, and does not warn him automatically by touch in case one slide in a set has been turned accidentally and the operator is mechanically feeding through the set after having tested the top slide of the pile. The inside thumb spot cannot be lost from the slide, and may be supplemented by an outside spot gummed on if the operator will take the trouble.

Where slides are in sets, as in slides for illustrating songs, the slides are numbered, the thumb spot sometimes being used for the number of the slide in the series.

THE LAMP

An oil lamp is sufficient for toys, an incandescent gas mantle or an incandescent electric-lamp bulb for a parlor exhibition. For larger rooms requiring a longer distance from the lantern to the picture screen, and requiring a larger picture upon the screen because of the greater number of people who are to view it and the consequent greater distance from the screen of the more remote spectators, a brighter illuminant is required. This is found in acetylene gas, in the lime light, or in the electric arc.

Acetylene. Acetylene is a gas produced for illuminating purposes by wetting calcium carbide with water. It produces a very brilliant white light, suitable for lantern projection, but not so brilliant as the calcium light or the electric arc. The acetylene light has the disadvantage of offering a comparatively large flame, whereas the calcium light (or lime light) and the electric arc both offer a light which comes from a very small surface, practically from a single point. The light from the point is better for projecting purposes.

Acetylene generators all provide a water tank and a carbide chamber. They vary in the method or means for admitting small quantities of water to the carbide chamber or small quantities of carbide to the water tank. In some generators, the water is carried to the carbide by soaking up a wick, the amount of gas generated being regulated by the speed with which the water can reach the carbide by soaking through the wick. The gas must be used as generated, and when not needed the generation is stopped by lifting the wick from the water. In others, the water drops upon the carbide through a needle valve which is capable of a regulation to give exactly the flow of gas required. In others, the carbide is placed in a floating chamber which is lifted from the water by the generation of gas, being lowered into contact with the water again when the gas is used. Any generator which accumulates gas under pressure is more dangerous than one in which no provision is made for storing the gas, and the gas must be generated exactly as required. Any gas generator suitable for supplying gas to automobile headlights is suitable for supplying gas to a projecting lantern, and the tanks of compressed gas much in favor for automobile lamps are suitable also for projecting lanterns. The only connection required between the gas supply and the burner is a single flexible rubber tube.

The gas burner, designed especially for projecting lanterns, has a row of jets in a straight line, placed endwise to the condenser. These are bunched as closely as possible, a group of four or six in a line having a length of an inch or an inch and a half. A reflector also may be used.

Lime Light. This is a form of incandescent gas burner. The "lime" is a cylinder of lime set upon a pin in such a manner that it may be turned and raised and lowered as well. A gas jet plays upon it and heats it to a white heat at the point where the flame of the jet touches the lime. The glowing lime gives a brilliant white light, all the light proceeding from a very small area of the lime cylinder. The projection from such a light is very good, but the light is troublesome and to a great degree unreliable. The lime burns into a pit at the point where the flame touches it, and must be turned at short intervals to bring a new spot under the flame. If not turned, the tongue of flame will be turned back by the curved walls of the pit and may even reach to the back condenser, striking it and cracking it. Sometimes also the lime without apparent reason splits and falls from its support. That means stopping the show until a new lime has been placed and the jet again properly adjusted.

The gas jet used for the lime light will use ordinary illuminating gas urged to a greater heat by a jet of oxygen; thus two rubber tubes are required leading to the lime-light burner. When the illuminating gas is not available, a supply of hydrogen and oxygen is required, or some of the many substitutes.

For many years, prior to the commercial exploitation of the electric-arc lamp for the projecting lantern, projection before audiences of any size or importance was made almost exclusively with the lime light, and much stage lighting for theaters was done with it. "In the lime light" is an expression not yet lost to the language, although electricity long since has routed the lime light from the theater. Instructions for the proper use and care of the lime light, including the making of the burners and of the gases to be used in the burners gas generators, gas washers, gas purifiers, gas saturators, and so on in innumerable variation, are found in abundance in books and magazines of a decade since, but the general subject has little interest to the modern optical-lantern operator or motion-picture projection operator.

The Electric Arc. The only modification of the ordinary electric arc required to adapt it for use in the optical lantern is to make it as much one-sided as possible, that is, to arrange it so that as much of the light as possible will be thrown toward the condensers.

The Direct=Current Arc. The positive pole is connected to the upper carbon of the lamp, the negative to the lower carbon. The carbons are placed end to end and in a straight line except that the axis of the lower one is slightly in front of the axis of the upper one, that is, toward the condensers. In the direct-current arc, a cavity or crater is formed in the positive carbon. The crater is the hottest and brightest point in the lamp, and from it proceeds the greatest amount of light. By displacing the negative or lower carbon slightly, say, an eighth of an inch, the positive or upper carbon is caused to burn with a diagonal end containing the brilliant crater, and the light of the arc, therefore, is thrown off to one side of the lamp, namely to that side toward the condensers. The proper relation of the carbons is shown in Fig. 6, and the direction of greatest intensity of light is shown by the dotted lines radiating from the upper carbon. To bring this maximum light upon the condenser surface, the line of the carbons must be inclined as shown, and at about the same angle, say, twenty to thirty degrees. If inclined too much, the end of the lower carbon will throw a shadow upon the condenser, and if not inclined enough the greatest brilliancy upon the condenser will not be obtained. In this connection it may be noted that the length of the arc governs to some extent the angle at which the lamp may be inclined, since with a longer arc a greater inclination may be had before the lower carbon shades the condenser from the crater. The carbons should be set parallel. If set at even a slight angle, the feed as the carbons burn away will change the displacement of the two ends and change the value of the light.

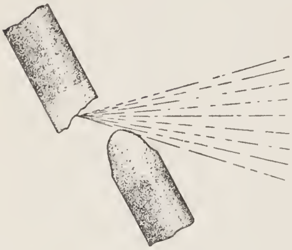


Fig. 6. Motion-Picture Arc for Direct Current

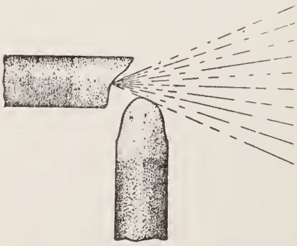


Fig. 7. Stereopticon Arc for Direct Current

A second method of setting the carbon for the direct-current arc is shown in Fig. 7. The positive carbon is set horizontally and when properly adjusted for position, points directly toward the center of the condenser. When fed, it moves directly toward the condenser, and thus always keeps its crater "centered," whereas in the adjustment of Fig. 6, the burning away of the upper carbon constantly raises the crater from the center line of the condenser, and the feeding of the upper carbon constantly lowers the crater. Unless the feed is exactly proportioned to the burning away, and exactly compensates for the burning away, the crater will get off the axis of the condenser and the lamp as a whole must be moved to bring it back. Unfortunately the adjustment of Fig. 7 does not give as brilliant an arc as the adjustment of Fig. 6 when a long arc is used, but when a short arc is used the carbons become so near in Fig. 6 that Fig. 7 becomes preferable and gives the better light.

Stereo vs. Motion Arc. Fig. 7 is called the *stereopticon arc*, and Fig. 6 is called the *motion-picture arc*. Stereopticon or fixed-slide projection, with the large slide nearly three inches square and enlarged to nine feet square on the screen, requires a magnification of thirty-six diameters. A fifteen-ampere arc is sufficient to give the illumination required; a forty-ampere arc gives so much heat that slides will be broken by the heat if left in the slide holder for many seconds. With a fifteen-ampere arc, the adjustment of Fig. 7 gives a better light than that of Fig. 6 because in Fig. 6 the carbons are brought so close to maintain the short arc that the lower carbon shades the condenser. Motion-picture projection, with the image only three-quarters of an inch by one inch, enlarged to seven and one-half by ten feet on the screen, requires a magnification of one hundred and twenty diameters—more than three times the lineal enlargement and more than ten times the surface enlargement of the stereopticon projection. A forty-ampere arc is desirable, and the longer arc adjustment between the carbons permits the adjustment of Fig. 6 to attain the greatest possible brilliancy upon the condensers. The heat is intense and would ignite the celluloid film almost instantly were the film to remain at rest in the heat, but the period of rest of the film is only one-fourteenth of a second for each picture, a period of time too short to permit it to begin to blaze.

The Alternating-Current Arc. In alternating current there is neither positive nor negative pole, and both carbons are alike in the lamp, each having a crater, but neither crater as hot for the same current value as the direct-current crater for the same current. When the carbons are set in line, the light of the alternating arc is distributed equally in all directions, but when they are set at a slight angle to each other the greater portion is thrown outward from the angle. The proper setting is shown in Fig. 8. The angle there shown is about as great as will be found possible to get the best light, but the angle between the carbons depends to some extent upon the amount of current used and the length of the resulting arc. A larger current is required with alternating than with direct current, from fifty to sixty amperes being common.

Cored Carbons. Carbons are made either with the same consistency of carbon through the pencil or with a hard shell and a soft core, the core being about the size of the lead in a lead pencil. When the cored carbon is used, the crater will form in the end of the core, keeping in the center of the carbon pencil, and the vapor of the soft core will hold the arc between alternations. With the alternating-current arc, the cored carbon is a necessity, producing the arc shown in the diagram of Fig. 8, whereas without the cored carbons the arc has a tendency to run to the nearer edges of the carbons, as shown in the diagram of Fig. 9, with consequent loss of brilliancy upon the condensers. The solid carbon is generally used in the direct-current arc. For one reason, it costs less money. The light will be found easier of control, requiring less skill on the part of the operator if the cored carbons are used on the direct-current arc also. Soft carbons give a better light than hard, but burn away faster and require more attention and adjustment.

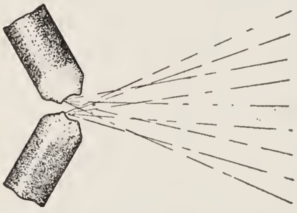


Fig. 8. Proper Arc for Alternating Current, with Cored Carbons

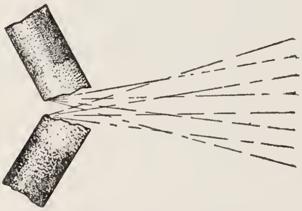


Fig. 9. Improper Arc for Alternating Current, with Solid Carbons

Lamp Adjustments. The lamp has four adjustments: (*1*) vertical, or up and down; (*2*) focusing, or back and front, toward and from the condensers; (*3*) lateral, or right and left; and (*4*) feed.

The vertical, focusing, and lateral adjustments for the position of the arc are mentioned in the order of their frequency of use. The feed is the adjustment of the carbons in the lamp, and should take place without changing the position of the arc; feed provides for the burning away of the carbons by the arc, the position of the arc being changed independent of feed by the three remaining adjustments. The different types of lamps made and sold by different manufacturers vary greatly in the details of the adjustments. In taking charge of a lamp, look for the four adjustments. The fourth or feeding adjustment will be found the most prominent, being the one most used. Invariably, it is controlled by a knob projecting from the back of the lamphouse. Turning the knob in one direction brings the carbons together and turning in the other direction separates them. To start or "strike" the arc, turn the knob to bring the carbons together, when a slight sputtering and a dim light will announce that the carbons are in contact; then reverse the knob quickly for a part of a turn to draw the carbons apart. The current will continue to flow through the separated carbons, and a brilliant arc will be formed. The proper adjustment is the brightest arc obtainable, all adjustments being considered. This is not the longest arc nor the shortest arc. With the long arc the current is reduced and the intensity of the light of the crater is less; while with the short arc the intensely brilliant crater is concealed between the two carbons. As the carbons burn away, the arc becomes longer and weaker and ultimately will "break" and die out, requiring that the arc be "struck" again by feeding the carbons down into contact and backing away as in striking the arc at first. The carbons must be fed down skillfully to compensate for the burning away before the arc breaks. The feed may be gauged through the peephole of the lamphouse, or by the illumination of the picture screen, or by the sound of burning in the lamp. At frequent intervals, feed down slowly; the illumination of the screen will become brighter to the maximum and then lose a little, indicating by the slight loss that the proper adjustment has been passed. Then back up slightly to the best adjustment and after a half minute or a minute feed down again in the same way. This method of feeding must be practiced so skillfully that the audience will not notice the slight changes in illumination by which the lantern operator is feeling the pulse of the arc.

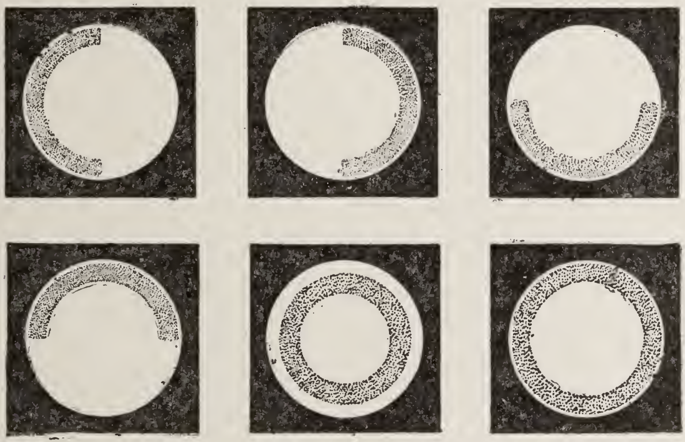
Angle of Carbons. The angle at which the carbons are set will vary with the amount of current used, and to some extent with the size and quality of carbons used. When, looking into the lamphouse, the front wall of the house is brighter below the condensers than above, tip the carbons to a greater angle; or bring them more nearly vertical, when the inner wall of the lamphouse shows brighter above the condensers than below. The same result is attained by rocking the angle of the carbons while watching the screen, and stopping where the illumination is brightest. Care should be taken in practicing with the adjustment to distinguish between the effect on the screen of changing the angle of the carbons and the centering of the arc itself.

For experiment, open the door of the lamphouse, watch the front wall, and draw the arc a little longer; the "brightest spot" on the front wall moves down, because by drawing the arc longer the end of the lower carbon has been drawn from in front of the crater of the upper carbon. To bring this brightest spot back to the condensers, the carbon must be tipped to a greater angle. But the longer arc should not be used unless there is current to support it without breaking. The production of a steady arc, not quite so bright, is evidence of better lamp operating than a brighter but irregular and unreliable arc—a "forced" arc. The amateur always lacks the skill required to force an arc successfully; the master of the lantern is too jealous of his results to practice it. A medium length of arc, steady of feed and steady in illumination, with the angle of carbon to throw the brightest spot of light straight into the condensers, is the proper adjustment. Many lanterns do not have the angle of carbons adjustable without opening the lamphouse.

Centering the Light. The proper burning of the lamp will determine the brilliancy, but its position in the lamphouse will govern the uniformity of the illumination of the screen. There are half a dozen rules for centering the arc, but all of them amount to this: *The screen shows the arc inverted just as it shows the lantern slides inverted, and the brightest spot on the screen must be brought to the middle. If the bright spot on the screen is above the center, raise the arc, for that will lower its image on the screen. If the arc is moved to the right, the bright central portion of the light on the screen will move to the left, correspondingly.* Most lanterns have the vertical adjustment possible without opening the lamphouse, but the lateral adjustment usually requires work inside the lamphouse door. Once correctly adjusted, it seldom requires changing.

In Fig. 10, a shadow shows at the left of the screen, the center of the bright image of the arc is at the right of the center of the screen, and the arc should be moved to the right in the lamphouse to bring the bright spot on the screen toward the left. In Fig. 11, the conditions are reversed, the shadow is at the right, and the arc should be moved to the left to throw the bright spot on the screen to the right, pushing the shadow off the screen. In Fig. 12, the shadow is at the bottom, and the arc in the lamphouse should be raised to lower the bright center of illumination on the screen; in Fig. 13, the shadow is at the top, and the arc in the lamphouse should be lowered to raise the bright center of illumination on the screen.

Focusing the Light. The cone of light passing from the front of the condensers should come to a point at the focal center of the objective lens. The length of this cone may be changed by shifting the light back and forth in the lamphouse, hence the point of the cone may be brought to the lens after the position of the lens has been determined. To find the proper position of the lens, place a slide in the slide holder and move the lens to focus the slide upon the picture screen. Then remove the slide and adjust the lamp to that distance from the condensers which will bring the point of the cone of light to about the middle of the lens barrel. The final adjustment for position of the lamp is determined by watching the picture screen, and the symptoms on the screen are illustrated in Figs. 14 and 15. With a bright margin upon the picture screen (no slide in holder) and with a central shadow or with a ring of shadow or of color about the center of the screen, the lamp is properly "centered" but is too



Figs. 10-15. Guide Chart for Lamp Adjustments

near to the condenser. This is shown in Fig. 14. When the lamp is too far from the condenser, the edges of the screen will be in shadow or show color. This is shown in Fig. 15.

LAMPHOUSE

A sheet-iron house or box contains the lamp and stops its light from blinding the operator and from illuminating the picture screen with the stray rays. The more frequently used adjustments of the lamp are all controlled by knobs upon rods projecting through the rear wall of the lamphouse, rendering possible all adjustments required while a series of slides are being shown, or while a motion-picture reel is being run, without opening the door of the house. The door is at the side and gives access to the lamp for the purpose of renewing carbons and of making such adjustments as ordinarily are required only in setting up the lamp for service. In the door of the lamphouse is a peephole, through which the operator may look at his lamp to determine whether the adjustment is approximately correct before projecting the light upon the screen.

Pinhole Image Peephole. A sheet-iron box an inch or an inch and a half each way with a No. 60 drill hole in the middle of the bottom and the open top placed against the peephole inside the lamphouse door will throw a pinhole image of the arc and carbon ends upon the glass of the peephole. This image will be visible to the operator from any angle, and it is not required that the eye be brought close to the peephole, nor even in line with the peephole and the lamp.

Sliding House. In a projecting machine adapted for motion pictures and lantern slides, the same lamphouse is used for the motion head and for the long-focus lens for fixed slides. With the motion head and the long-focus stereopticon lens mounted upon the projecting stand side by side, the lamphouse is slidable upon a short track so that it may be pushed from the motion head to the stereopticon lens, or pulled back to the motion head. Stops at the end of the track are adjustable, for centering the lamphouse properly upon the motion head or lens at its two positions.

An old arrangement is to have the motion head and stereo lens upon a pivoted platform which swings in front of the lamphouse to bring either the motion head or the stereo lens in front of the lamp.

Ventilation. Openings in the bottom and in the top of the lamphouse permit a current of air to carry away much of the heat of the lamp. A precaution to be observed is that the current of cold air, incoming through the bottom holes, does not strike the face of the condensers, as such a draught may crack the condensers. Wire gauze over the holes in the bottom of the lamphouse will break up the incoming column of air and usually will reduce condenser breakage.

Guard. The top of the lamphouse sometimes gets so hot that a piece of motion-picture film will burst into flames when touched to the house. To prevent accidental contact, the top of the lamphouse may have a guard of wire screen, extending over the edges.

CONDENSERS

The object of these large glasses in the optical system is to get more light into the lens from the lamp. Their efficiency is so great and their cost is so low that all lamp systems use them—indeed, it is thought by operators who have not given their work a thought that projection without condensers is quite impossible. A very good quality of projection is possible without condensers when using a lantern built for use without condensers. Even with a lantern built for use with condensers it is possible to accomplish, in an emergency, a projection which may serve to entertain an audience and save the humiliation of dismissing and disappointing the people altogether.

Development. The development of the condenser as it is generally used today in projecting lanterns is shown in diagrams in Figs. 16 to 21, inclusive. Fig. 16 shows a system in which the arc lamp at the left throws its rays directly upon the slide at *S*. The rays of the lamp pass through the transparent slide and proceeding then in straight lines pass for the most part outside of the lens at *L*. The lens gets a few of the rays—that small

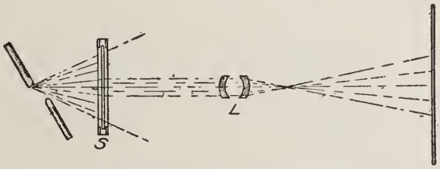


Fig. 16. Development of the Modern Type of Condenser. Double Lens Only

bundle of rays passing through the middle of the slide directly in line from the arc lamp to the lens—and these rays the lens throws into focus upon the picture screen at the extreme right of the diagram. The result is a picture upon the picture screen which covers only a small spot in the middle of the screen and which shows in that spot only a small portion of the slide, the central portion. If only a small slide were used, such as a slide from a toy lantern, in which the entire picture is as large as a ten-cent coin, the entire picture of this diminutive transparent slide at the left would be thrown upon the picture screen at the right. That is one type of projection without a condenser. The slide must be smaller in size than the lens which focuses it upon the screen, so that all the light passing through the slide may find its way into the glasses of the lens. When it is desired to project a slide in which the picture is three inches in diameter (and the usual lantern slide is about that diameter measured from corner to corner), a very large lens would be required. Notice also that the light after passing through the slide at *S* spreads very rapidly, so that if the lens were placed closer to the slide the lens would not have to be so large in order to catch all of the light passing through the slide.

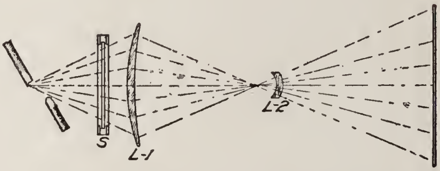


Fig. 17. Development of the Modern Type of Condenser (Rear Combination of Lens Enlarged)

A modified lens is shown in Fig. 17, which has great light-gathering power without going into the expense of several large glasses. One of the glasses of the lens is made larger than the slide to be projected and is positioned at *L-1* near the slide, catching the rays soon after they have passed through the slide and bending them into the remaining glass of the lens, shown at *L-2*. In this way, practically all of the light of the lamp which passes through the slide is caught by the lens *L-1* and is bent into the lens *L-2* and thus is brought into effect in producing the picture upon the picture screen at the right. The system of this stage of development is further

SCENE FROM PHOTOPLAY, "THE MASTER AND THE MAN"
Courtesy of *Independent Moving Pictures Co., New York*

improved by using the full double lens at the point *L-2*, as shown in Fig 18, the large lens close to the slide being thus made an auxiliary piece of glass, although forming a part of the total lens system. Considered as a glass apart from the lens, and seeking a name for it, it is noticed that it has the power of gathering the light coming through the picture slide and squeezing the rays together or condensing them into the glasses of the main object lens, or lens proper, *L-2*. Considered from that point of view, the name of "condenser" appears to be fitted to the glass in a descriptive way; no one has suggested a better name for it, hence "condenser" it is called.

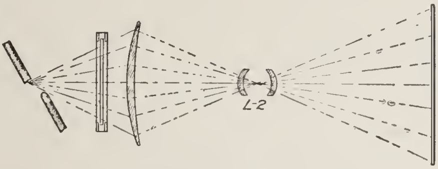


Fig. 18. Development of the Modern Type of Condenser (One Condenser Lens Added)

With the auxiliary lens at its position given in Fig. 18, bending the light after the rays have passed through the picture slide, it is necessary that the lens be of a high grade of glass and that it be very accurately ground, any distortion being noted upon the projected picture at the right. Experiment shows that the auxiliary lens may be placed upon the other side of the picture slide, as shown rearranged in Fig. 19; that in that position it is equally effective in concentrating the light into the lens at *L*, and that when so placed its slight inaccuracies are not so clearly visible in the picture at the right, which is the picture to be viewed by the audience. This permits a condenser to be made of cheaper glass, and with less accurate and less expensive workmanship. With the condenser placed in the position shown in Fig. 19, the condenser may be said

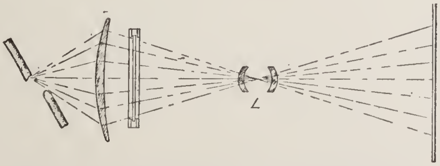


Fig. 19 Development of the Modern Type of Condenser (Condenser Behind Slide)

to condense the rays into the lens at *L*, but the optical system of the lantern may be better studied and understood, the lantern may be more conveniently analyzed for troubles when something goes wrong, its total adjustment may be more quickly attained and maintained, in short, better work can be done, by considering the condenser as related to the lens, not to the slide, and in considering the condenser as a part of the lens itself, as indeed it is. Consider the lens system as consisting of all the glasses through which the light passes on its way from the arc lamp to the picture screen, and consider that the slide to be projected is inserted into this complete system between two component parts of the lens system.

Condenser a Part of the Lens. Unless the operator gets the mental conception that his condenser is a part of his lens, he is likely to overlook the fact that for good pictures his condensers must be focused into his lens, believing it sufficient that his lens is focused upon the picture slide.

Clip an illustration from a magazine or newspaper, moisten and rub off the printing from the back of the clipping, if printed on the back, and put this clipping into the lamphouse, the picture side against the glass surface of the back condenser. The stereo lens may be adjusted to focus the picture upon the screen. With accurate condensers the image on the picture screen would be sharp, but with cheap condensers it will be much distorted and blurred in some places.

This simple experiment, however, will show that the condensers are a part of the lens systems of Figs. 19, 20, and 21, and as much as they are in the systems of Figs. 17 and 18.

Plano=Convex Condensers in Pairs. Three forms of condensers are shown in Figs. 19, 20, and 21—the *meniscus* in Fig. 19, the *convex* in Fig. 20, and the *plano-convex* in Fig. 21. In each of these systems, the condenser is shown as throwing into the lens all of the light which it catches from the lamp. The more light which the condenser can catch from a lamp of a standard of brightness, the more light will the lens and, therefore, the picture screen receive and, therefore, the more desirable does the particular form of condenser become. The plano-convex condenser—probably because it presents a flat face to the lamp—has the power of picking up more rays of light and of standing the heat of the lamp without breaking better than any other form of condenser of equal price.

The plano-convex condensers are used in pairs, the first of the pair, that nearest the lamp, having the function of bending the rays into parallelism; then they pass to the second condenser which bends them again and throws them into the glasses of the objective lens.

Focal Lengths. The theoretical requirement of the condenser glasses in bending the rays involves glasses of different focal lengths to attain the condition of adjustment in which they will give the most effective results. For theater projection, both for stereo or lantern-slide projection, and for motion-picture projection, this requirement involves the use of a glass at *C-1* nearer the lamp, Fig. 21, of shorter focal length than the glass at *C-2* farther from the lamp, but such is not the practice. The difference in the projected picture upon the screen is slight, and the convenience of using both glasses alike is so great in comparison that the custom of most operators is to use two glasses of the same focal length. In this use, the first lens does not bend the rays quite as much as it should, and they are still slightly divergent between the condenser glasses, resulting in the loss of some light around the edge of the second glass, with consequent slight lack of brilliancy in the picture upon the screen.

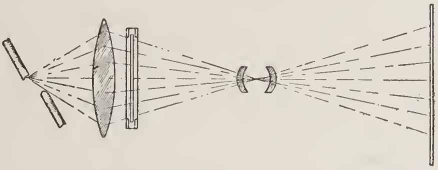


Fig. 20. Development of the Modern Type of Condenser (Double Convex Condenser)

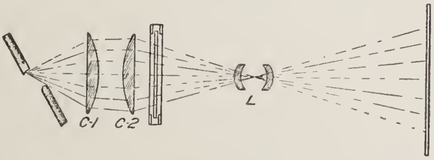


Fig. 21. Development of the Modern Type of Condenser (Present Condenser System)

Theory makes the condenser glass *C-1* of Fig. 21 about six inches focal length, and the condenser glass *C-2* of that figure about two inches longer than the focal length of the stereo lens *L*. Two sixes is the usual combination for service. The condenser has the peculiar feature that any length of condenser glasses will make some sort of projection. The operator who realizes that his condenser is a part of his lens will improve his projection by bringing the two into harmony as far as possible.

Projecting machines are equipped with condensers by the manufacturers and are shipped with fixed distances between condensers and motion head without reference to the focal length of the lens to be used in the motion head, and the focal length of the condenser is not regulated to the length of the stereo or lantern-slide lens nor with reference to the focal length or position of the optical center of the motion-head lens, since neither is known at the factory, the size of screen and the length of throw from the projecting station to the picture screen being unknown. If the condenser lengths are inaccurate, the optical system as a whole may be corrected by determining the proper position of the lamp to bring the rays bent by the condensers to cross at the optical center of the lens, the optical center of the lens being previously determined by focusing a slide upon the screen.

Adjustment for Slides or Motion Head. In a lantern having stereo lens and motion head, the distance from the condensers to the optical center of the stereo lens may be different (probably is different) from the distance between the condensers and the optical center of the motion-head lens. This condition requires that for good pictures the position of the lamp in the lamphouse must be changed each time the lamphouse is moved from motion head to stereo lens, or *vice versâ*. The proper adjustment, when once learned, may be attained by noting the size and the shape of the spot of light around the film window of the motion head, or upon the edges or light guard of the stereo lens.

Emergency Projection. With reference to condensers, emergency projection means projection when there are no condensers available. A cracked condenser is serviceable as long as it holds together—it is better than none. With the motion head, either or both condensers may be cracked, and the picture on the screen will not show it. With the lantern slide and the stereo lens, the back condenser will show its cracks less than the front condenser, but any crack in the front glass will show plainly upon the screen. It is when the condenser glass falls to pieces and drops out of the cell that the operator is required to adopt emergency methods to save the show.

With one condenser gone, put the remaining condenser in the front position—the *C-2* position of Fig. 21—and move the lamp back in the lamphouse until the rays after passing through the condenser cross at the optical center of the lens; if the lamp cannot be moved so far, move it as far as possible. The picture upon the screen will be of the usual size, but of much less than usual brilliancy. If the edges are dim, and a longer lens is available, use the longer lens, thus reducing the size of the picture and increasing its brilliancy.

In the motion head, the stereo lens even may be moved to a position in front of the motion head and the regular motion-head lens removed, projecting the motion pictures through the stereo lens. The resulting picture upon the screen (taking the usual run of motion theaters) would be about four feet wide by three feet high, but bright, sharp, and distinct with the one condenser.

Diffusion Projection. With both condensers lost, use ground glass instead—four sheets, two with the smooth sides together for the back condenser and two with the smooth sides together for the front condenser. They are diffusers rather than condensers, but they will give upon the screen a picture of full size but lacking in brilliancy if the usual objective lenses are retained. The longest available lenses should be used, sacrificing something in size and gaining something in brilliancy.

Adjustment of the Optical System. Select the motion-head lens for focal length according to the lens table, selecting it for the length of throw from the lens to the picture screen and for the size of picture desired upon the screen.

Place a piece of film or a piece of scratched mica in the film window and focus it upon the screen. The lens being a double lens, *i. e.*, a lens tube having glasses at both ends, it may be taken that the optical center of the lens is at the center of the tube

The length of focus of the front condenser glass, *C-2* of Fig. 21, should be equal to the distance from the focal center of the motion-head lens to a point midway between the two condenser glasses. It may be less, rather than more.

The length of the focus of the back condenser glass—*C-1* of Fig. 21—should be about six inches. A longer length of focus will reduce the breakage due to the heat of the lamp, while a shorter length of focus will give a brighter light upon the screen but probably with greater breakage, because the lamp will be brought nearer to the glass.

Push the lamphouse away from the motion head so that the cone of light will pass at the side of the motion head; then adjust the lamp until the cone of light "crosses" just at the side of the motion-head lens and opposite the focal center of the lens. The point where the cone of light crosses is the point where the solid beam of light coming from the condensers reaches its smallest diameter and then begins to spread toward the picture screen. As the lamp is moved forward in the lamphouse, this point of crossing moves forward away from the condensers and toward the picture screen. As the lamp is moved back in the lamphouse, the point of crossing is drawn back toward the condensers. Stop it opposite the focal center of the motion-head lens. Then draw the lamphouse back to the motion-head and notice the appearance of the circle of light about the film window.

The appearance of the circle of light around the film window when the lamp and the optical system are in proper adjustment should be remembered by the operator as a standard. Before opening the film-window shutter to begin projection, the circle of light may be brought to that standard as nearly as the operator can remember it and little or no adjustment will be required to improve the projected picture after the film window is opened.

The optical system having been adjusted to the requirements of the motion head in preference to the requirements of the fixed slide and stereo lens, the process may be repeated for the stereo lens.

Select the stereo lens for focal length according to the lens table, selecting for length of throw and size of picture desired. To produce a picture of comparative size, the length of the stereo lens will be about three times that of the motion-head lens.

Place a slide in the carrier and focus the slide upon the screen. The lens being a double lens, it may be taken again that the optical center is at the center of the tube.

Draw the lamphouse to one side and again adjust the lamp to cause the cone of light to cross at the center of the stereo lens. Notice the appearance of the circle of light, or of the cone of rays as it enters the stereo lens. This appearance may be remembered and will help in making a proper adjustment quickly for the projection of lantern slides.

The cone of light usually is visible in the room by reason of the dust motes floating in the air. If it is not visible for this cause, its formation may be studied and the point of crossing may be determined by holding a white card in the cone of light and moving it toward and from the condenser until the circle of light upon the card is at its smallest, which will be the point of crossing.

It is a great convenience in changing from motion-head to stereo lens if they can be so placed that readjustment of the lamp in the lamphouse will not be required. This can be accomplished by moving the motion head toward or from the lamphouse to bring the focal center of the motion-head lens opposite the focal center of the stereo lens.

A lamp adjustment taken by many operators is that lamp position in which the circle of light upon the film window is reduced to the smallest circle possible which will fill the window. This results in a brighter picture upon the screen in spots, but the distribution upon the screen may be irregular in intensity and objectionable coloring is likely.

THE SLIDE CARRIER

Just in front of the condensers is placed a frame for holding the picture slide. A part of the frame is made to slide, and is provided with windows and grooves for two picture slides. The movable part of the frame is arranged with stops at both ends of its travel so that it will stop with one or the other of its two picture slides in proper position for projection by the lamp and lenses upon the picture screen, the other picture slide being at that time out of the light of the lantern, waiting for the frame to be pushed across into its other position to bring the waiting slide into proper position for projection. The second slide being thus brought into the light of the lantern, the first slide is removed from the carrier and the third slide is put in its place. The carrier then is pushed back into its first position, showing the third slide upon the screen, and so on, the slides being placed in the carrier first at the right and then at the left, the carrier changing ends for each change of picture upon the picture screen.

Simple Form of Carrier. The simple form of slide carrier is shown in the illustration of Fig. 22. The fixed frame comprises a track across the bottom and an open frame at the middle of the track.

Within the frame is shown the slide carrier with its two windows, the carrier being shown slightly out of center.

The carrier has grooves open at the top into which the picture slides are slipped when they are to be projected. Some carriers have a single groove, four inches wide, admitting the American standard size of slide, which is $3\frac{1}{4} \times 4$; in this type of slide carrier it is necessary to center carefully a foreign slide measuring only $3\frac{1}{4} \times 3\frac{1}{4}$ that it may appear centered upon the screen when the slide carrier is pushed over. The picture of the American slide is the same size as that of the foreign slide, the additional area being blank margin.

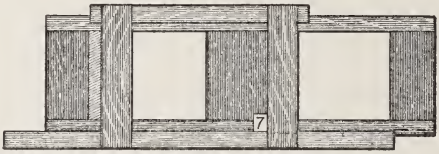


Fig. 22. Simple Slide Carrier

Carriers for American and Foreign Slides. Slide carriers for exhibiting both the American and the foreign sizes of slides may have a pair of centering springs which push either size to the center of the window, or may have two grooves—one wide for the American slide and one narrow for the foreign slide; in the latter case, in showing a mixed set of slides it is necessary to change the focus adjustment of the stereo lens each time the slide changes from one groove to the other.

Slide Window Masks. In Fig. 23 is shown a masked slide window. No matter what the size of the slide placed in the carrier, only so much of its picture will be shown upon the picture screen as may be seen through the mask (shown as a black frame) in the slide window.

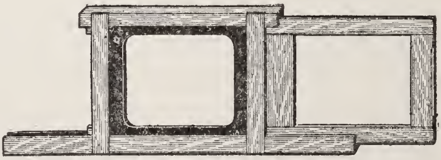


Fig. 23. Slide Holder Window Mask

The slide-window mask is a boon to the operator who cannot make his lens cover his slide. Just put in a mask that the lens will cover. The average set of song slides will be more pleasing with the edges trimmed away by the sharp cut of the slide-window mask than with the corners trimmed away by fading first into color and then into darkness by reason of the failure of the lens to cover the field.

Slide=Window Shutters. When the view upon the screen is changed merely by pushing the carrier across, the old view races off of the screen at a high speed and the new view races on. This is considered objectionable by some people, although it is a matter of opinion whether some of the cures are not worse than the malady.

To cap the lens or to operate a small manual shutter or even a pedal shutter while moving the slide across is the simplest remedy. Devices are offered in connection with complicated slide carriers by which the slide window is closed by an automatic shutter except when the carrier is in one or the other of its end positions. By pushing the carrier across quickly, the interval of darkness caused by the shutter becomes very brief. The interval of darkness, no matter how brief, is objectionable, as the pupils of the eyes in the audience begin to expand and again must contract for the succeeding picture, repeating this at every change.

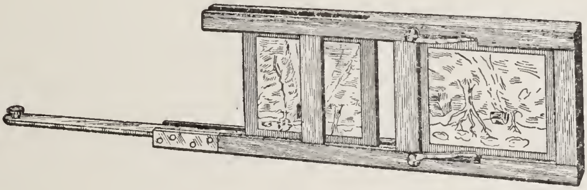


Fig. 24. Slip Slide Carrier

Slip Slide Carrier. In the slip slide carrier, shown in Fig. 24, the slide at the right is in the window for projection and the slide at the left is the new slide next to be projected. The lever and knob at the left engage the new slide and push it into a position in front of the slide already on the screen. Thus both slides are thrown upon the screen in confusion for an instant. The pawls of the controlling handle are released from the new slide when it reaches its position for projection and engage the old slide to withdraw it, so that by the return of the operating handle the old slide is withdrawn, leaving the new one in position in the beam of light. As the old slide is drawn from under the new one, a set of springs presses the new slide down into the position formerly occupied by the old slide, that is, into the position of proper focus for the lens. The change of slides can be made very quickly. A modification of this device carries an opaque shutter which closes the slide window as the new slide comes in and opens it as the old slide is drawn out, thus avoiding the confusion of projecting both slides at once.

Mechanical Slide Changers. Mechanical changers take two forms, which may be classified as *semi-automatic* and *full automatic.* In the semi-automatic type of changer, the object desired is to have the view changed at the desired instant. This is of value in lectures, and in illustrated songs as well. Such a device consists of a spring for drawing the carrier across, with a lever for setting the spring to tension, and an electromagnet for releasing the carrier. The operator in the projection room places the new slide in the carrier and sets the spring to tension to draw the carrier across. When the lecturer desires to have the new slide projected he touches a push button or electric switch which releases the slide and the spring draws it across. The operator at the lantern then replaces the old slide with the next of the series, sets the spring to draw the carrier back, and again waits until the lecturer has released the carrier electrically. In the case of the illustrated song, the stage director, the orchestra leader, or the pianist would change the slides by the push button.

For the dissolving lantern the operator changes the slide in the dead lantern and sets the dissolving shutter to tension. The control exercised electrically by the lecturer or musician then releases the dissolving shutter to change quickly to its other position, making the quick shift from slide to slide.

In the full automatic changer, the slides are placed in a rack containing a space for each slide, and this rack or multiple carrier is stepped forward, step by step, either under control of the projection operator, the stage director, or a musician in the orchestra. The rack for holding the slides in the full automatic changer takes the form of a wheel with the slides on the edge, a chain with the slides in the links, or of a nest of carriers in which slide after slide is brought into an operating position and then forced into position in the beam of light for projection. Full automatic changers are much used in windows and in public places for the projection of advertising slides, the changes being controlled by clockwork.

Storage of Slides. Sets of song slides come packed in small wooden boxes, and between repetitions of the song they lie stacked upon the operator's table, lying close upon each other, with no opportunity to lose the heat of the lamp acquired while being projected, and getting hotter every time the set is run through the lantern. Occasionally one or more are knocked from the table and the set is run a slide or two short thereafter, either the operator or the theater manager paying for the breakage. A slide storage-box like that shown in Fig. 25, but preferably with the hinges taken from the lid so that the lid may be removed completely while operating but replaced when desired, will keep the slides in order, prevent accidental breakage, prevent the insertion of a slide in the carrier in reversed or inverted position, and give the slides a chance to cool between successive projections. The announcement slides are kept in one end, the song slides in the other. The cost of one good slide or two cheap slides is about the price of such a box.

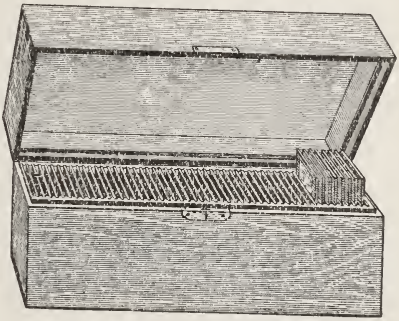


Fig. 25. Slide Storage Box

DISSOLVING LANTERNS

Up to the time of the introduction of the motion picture, the dissolving lantern was the most interesting of all optical illusions, and a favorite means of entertainment. It was developed to such refinement of detail that motion in projected pictures was well simulated in many instances. Entire scenes were played through with the very complete sets of lantern slides made and used with multiple lanterns, some sets of pictures requiring four or six lanterns working simultaneously upon the screen to produce the effects as planned.

Triple Lantern. In Fig. 26 is reproduced an illustration taken from an old book upon the subject of the optical lantern. It shows a triple lantern, three lanterns built in one, with tubes and dissolving valves at the back for the oxy-hydrogen or lime light. It was with such lanterns as this that truly "dissolving" effects were produced.

Imagine a rural scene, showing woodland, meadow, and lake. It is winter, and winter with a single lantern, winter with a single slide. By an auxiliary slide, in the same lantern, skaters appear and glide over the surface of the little lake. The skaters pass off the side of the picture and the scene again is still, with a single lantern. Now the picture begins to darken; soon only patches of snow are left here and there. The view has been dissolved from the first lantern used to another lantern with a slide similar and registering exactly but with less snow. Two or three or more successive slides are dissolved each into the next of the set before the snow is entirely gone and the view remains in the neutral colors of March,

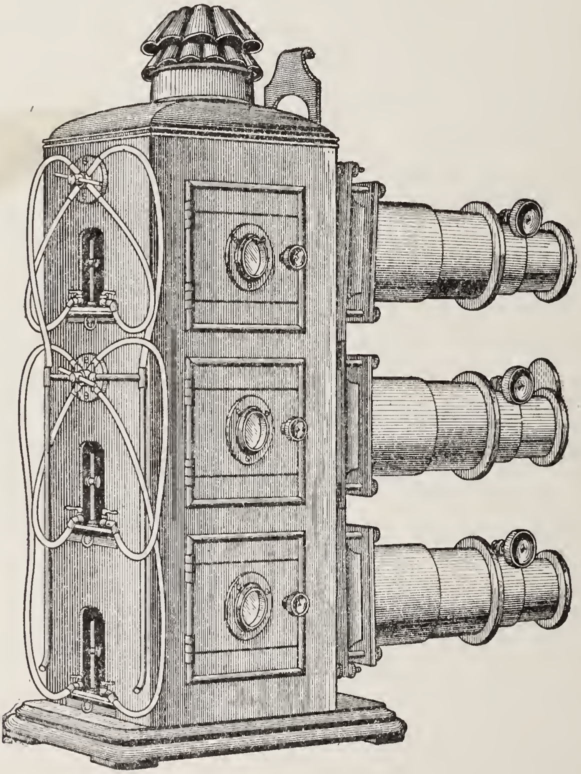


Fig. 26. Triple Lantern for Dissolving Projection

but with, yes, at first it seems elusive, but surely there is a suggestion of green in the meadow, positively now, and the darker green of the meadow is supplemented by a lighter green in the treetops. The branches begin to lose themselves in the mass of growing foliage, all in full color, and summer is here. How many slides have been used in the change is known only to the men behind the machines at the projection station; the audience, apparently, has seen but one lantern slide, but one view, in which not a tree nor house nor post of fence has moved, yet a view which has changed before their eyes in a manner even more wonderful than the changing of the modern motion picture, whose flicker betrays at once its mechanism and its origin.

In the summer scene (from one lantern) the lake is no longer ice and a white swan (from a second lantern) glides upon its surface. Clouds begin to appear in the sky (dissolving the view from the first lantern into a third lantern while the second lantern holds the swans moving upon the lake). The swan disappears and lightning begins to flash (from the swan's lantern), the rain begins to fall (view from the third lantern, rain from the first lantern, lightning from the second lantern), the clouds move across the sky (mechanical attachment for the third lantern), and the storm rages, as with the modern motion-picture film, sheet-iron thunder, bean-bag rain, and wind drum, complete.

The lightning ceases, lights appear in the windows of a house; presently the rain ceases and the clouds begin to break, and by and by the view dissolves into a moonlight scene with drifting clouds, ultimately giving a clear sky, moonlight sparkling on the surface of the lake, etc.

A notable set of slides showed the burning of a building, the breaking out of the fire, the arrival of the fire brigade, etc.

From this origin and from this field of activity comes the dissolving lantern of the song slide set, where its duty now remains solely to shift from one slide to some other probably quite unlike it, the dissolving function of the lantern being operative merely to save the eye of the spectator from the shock of other methods of change.

The Double Lantern. The modern dissolving lantern consists of two lamphouses, most conveniently mounted one above the other, although the arrangement of having them side by side has been tried. Each lamphouse is equipped with lamp, condenser, and lens system, slide carrier, and a shutter. The two shutters of the two lanterns are operated by a single handle and are so arranged that as the handle is moved one shutter is gradually closed and the other gradually opened. If in connection with a motion head, the lower lamphouse is arranged to slide for the stereo lens or for the motion head, the upper lamphouse being fixed in position. Slides are projected successively by placing the first slide in the lower carrier, the second in the upper. The first projection is made from the lower

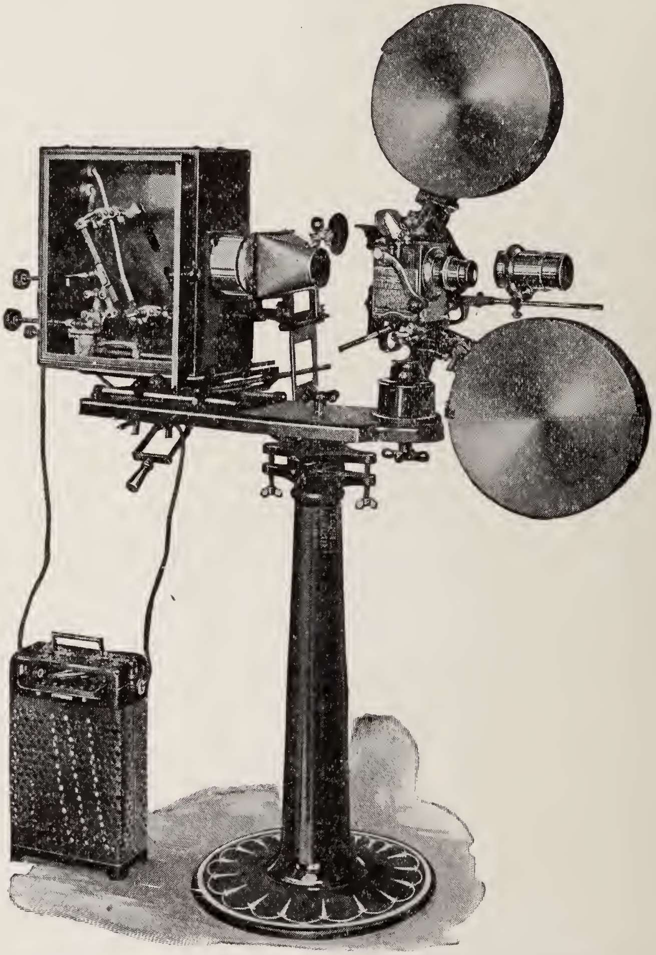


Fig. 27. Combination Projector, for Motion and Fixed Pictures, with Single Lantern

lantern, the handle is shifted to change the shutters, the slide is changed in the lower lantern and the handle again is moved to change the shutters, when the slide in the upper carrier is changed. The slide carriers in such lanterns may be of simpler or more convenient form than in the single lantern. The pictures projected by the two dissolving lanterns should be of the same size and carefully lined up together upon the screen. Modern single and double lanterns for motion head and dissolving slides are shown in Fig. 27 and Fig. 28.

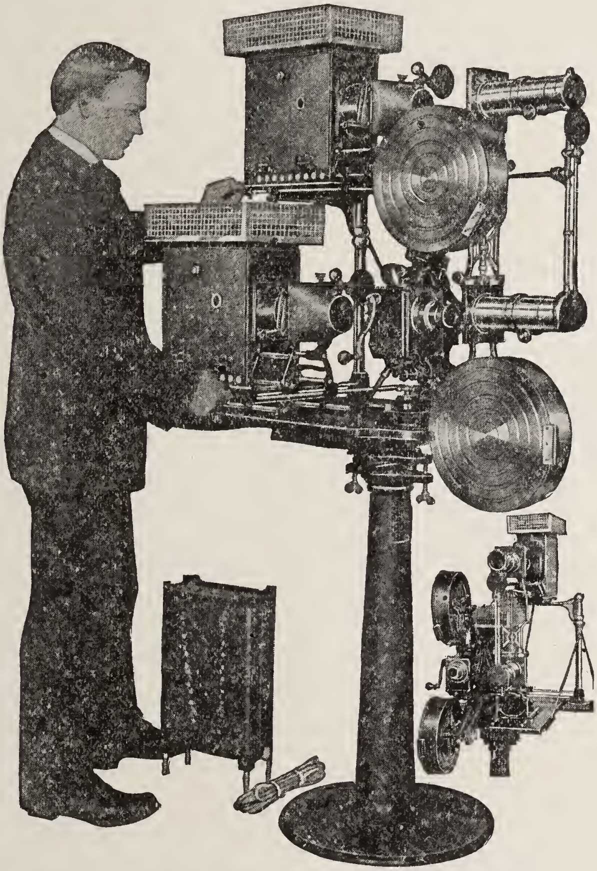


Fig. 28. Combination Projector, for Motion and Fixed Pictures, with Double Dissolving Lantern

Lining Up the Double Lantern. In setting up the projecting lantern with motion head, care should be taken to bring the two pictures into approximately the same position upon the screen, although the pictures from the motion head and from the stereo lens will be of different shape and may be widely different in size unless the lenses are carefully matched. In setting up the dissolving lantern the two pictures from the lanterns should coincide just as accurately as it is possible for the operator to make them. Adjustment screws will be found on the upper lantern for this purpose.

Alignment Masks. Considering the inaccuracy of slide masks in commercial sets of song slides, it is impossible to secure perfectly the desired result in dissolving without slide-window masks, such as shown in Fig. 23. With two such masks, cut from thin, ferrotype iron, or any thin sheet metal, of the same size and shape, and with two stereo lenses matched to exactly the same focal length (the lens makers will sell two matched lenses for an extra charge for matching), it is possible to dissolve without slides from one lantern to the other without showing any change in the edges of the white field of the screen. With this arrangement, good effects will be obtained with dissolving slides which are large enough to fill the windows.

Dissolving Shutters. The dissolving shutters should be set to close each lens half when the lever is in the middle of its travel. The light should be cut off just in front of the lens, near the lens, preferably with a shutter having a saw-tooth edge operating from one side with a horizontal movement across to the other side. The shutters, having two wings which cut off the edges of the lens first, leaving the middle of the lens effective until the last, and also the iris shutters which work between the lens glasses, inside the lens tube, and shut off the light beginning with the outer edges and gradually narrowing it down to a smaller opening in the middle of the lens until finally the light is stopped altogether, are fallacious in theory, for this reason: By such shutters, the volume of the light is reduced but the definition of the fainter image upon the screen is increased. With the shutter two-thirds over, the new image has twice the brilliancy, but the old image has greater definition—an objectionable feature. In the simpler cut-off working from one side only, the definition is impaired as the volume of light is diminished and the vanishing picture fades away in a blur which the eye cannot follow, the eye acting to pick up the new picture as soon as that picture has the greater light volume, it having also from that time the greater sharpness of definition as well.

SCENE FROM PHOTOPLAY, "THE CARDINAL'S EDICT"
This Scene Reproduces the Famous Painting, "The Struggle," by Meissonier
Courtesy of *Thomas A. Edison, Inc., Orange, N. J.*

Equipment of the Second Lantern. The second lantern, or upper lantern of the double lantern, should be complete and as far as possible separate from the lower lantern. Positively it must have a rheostat separate from that of the motion-head lantern, with separate switch for opening its electric leads and separate wiring from the switch through the rheostat to the lamp. Obviously, the lower lantern may be called upon for use in the ordinary way for motion and fixed projection without dissolving, in case the upper lantern is out of order, or the supply of carbons runs short; it is advisable also to have the upper lantern complete for similar use alone, removing it from its higher position to the lower. The lower lantern should have the double-slide carrier which it would require if the upper lantern were not used.

Operation of the Double Lantern. With electric lamps in the lanterns, the lamps are burned all the time of dissolving projection, since the striking and regulating of the arc requires too much time to be repeated for each new slide. During the projection of a roll of film with the motion head, the upper lantern may be cut out, striking the upper arc again while the lower lantern is projecting an announcement slide or a song title slide through its stereo lens. The upper lantern requires the same care as the lower, and its condensers should be identical with those of the lower lantern, adjusting it to match the lower lantern in every way. With condensers of the same focal length, the lamp must be adjusted to give the same appearance of the circle of light upon the back of the stereo lens tube. The rheostat of the upper lantern must have the same resistance as that of the lower lantern, and should be of the same construction to have the same radiating capacity. The same class of carbons should be used for the two lanterns, and the carbons should be set at the same angle.

Single=Lantern Dissolvers. If the perfect single-lantern dissolver has been produced, it at least has not come into general use. The object of the single-lantern dissolver is to fade the picture screen from one picture to another in the manner in which the double lantern dissolves a view into a dissimilar one (no reference to the older *art* of dissolving), the result being accomplished with a single lamphouse. The slip slide carrier is a compromise effort in this direction.

A promising dissolver for single lanterns is arranged as follows:

The slide carrier is moved forward from the condensers until a separation of about three inches is attained; then a forty-five-degree mirror is mounted slidably between the condensers and the carrier to reflect the beam of light toward the ceiling, a second slide holder and second objective lens are arranged in the vertical beam of light, and a second mirror is arranged above the vertical objective lens to reflect the beam of light toward the picture screen. The first slide being projected by the lower or horizontal lens, the second slide is placed in the holder of the vertical system and the mirror is slid in to transfer the beam of light from the slide of the horizontal to the slide of the vertical lens system. Shutters are not required for the lenses. This gives the effect of changing pictures by moving a vertical line across the picture screen from side to side, the old picture disappearing before the line and the new picture appearing after the line.

A modification is the substitution of a piece of polished clear plate glass for the mirror, leaving it always in its reflecting position when projecting lantern slides, whereby the light of the lamp is divided between the horizontal and the vertical lenses of the system. With this arrangement, a pair of dissolving shutters may be used and the fading of the entire view at once into the next view is obtained as with the double lantern.

Precautions in Dissolving. With the electric arc as a lamp, and with both arcs burning all the time during the exhibition of a series of views, the only danger to the picture screen is the projection of ludicrous combinations of two views, either successively shown or during the interval of superposition, when both are upon the screen together.

Reversals. The slides must be put into the carriers right side up (which is "head down" in the carrier), for an inverted slide is just as comical in the dissolving lantern as anywhere else. A "reversed" slide, however, may be rather more comical in a dissolving lantern than in a single lantern. By "reversed" slide is meant a slide which is put into the slide carrier "head down" but with the wrong side of the glass turned toward the lamp, reversing the picture on the screen right for left. With the same scene on two successive slides, probably with a change only in the position of the figures, as frequently occurs in song slide sets, dissolving one scene into the other with one of the slides reversed produces the crazy effect of a prominent feature of the scenic setting disappearing from one side of the scene and appearing simultaneously on the other side, every fixed detail of the scene changing places similarly, as though the scene were upon a revolving stage acting under control of some magician's wand. This is avoided easily by arranging the slides properly in their boxes before starting the series.

Slide Alignment. Where two slides follow each other with the same scene setting, the slides apparently having been made from negatives made without changing the position of the camera, it is desirable to bring the two views into alignment so that the trees and the other fixed objects will not be "doubles" on the screen during the act of dissolving. Knowing this particular feature of the two successive slides, the dissolving shutter may be opened upon the second slide so slightly that the audience will not note the coming of the new picture, yet the operator may be able to note some particular visible detail and bring the new picture into alignment with the old by moving the slide carrier of the new slide. Then proceeding with the dissolving shutter very slowly, the figures of the scene alone changing slowly and the fixed objects remaining upon the picture screen as though but one slide were being shown, the effect is delightful and well worth the effort required to attain it. It is a step toward bringing to life again the old art of the dissolving lantern.

The operator who desires to attain this effect and who fortunately has a set of slides with two slides in it capable of the effect, always can secure the required alignment by gluing bits of paper, card, or match sticks to the top edge and to the side edge of one or the other of the slides, carefully bringing them into alignment upon the screen before showing the set before an audience. In this case, the slide arranged for the lower lantern in the preliminary alignment must be projected from that lantern when the effect is desired, for it is most unlikely that the two lanterns themselves will be so perfectly adjusted as to permit the slides to be projected interchangeably from the two carriers and get the proper alignment for dissolving in both cases.

The utter extinction of the old art of the dissolving lantern is much regretted. Slide makers as well as lantern operators are to blame, the makers either forgetting the subject altogether, or taking for granted that the operators do not know how to dissolve.

Many sets of song slides show a face in a flower, in a bouquet, or in a medallion, or some fixed setting equivalent to a frame. A slide showing the bouquet without the face, dissolved skillfully into a slide showing the bouquet or other device with the face, would please the audience. Just for the simple reason that it would please the audience, the theater manager would like to have it and the slide maker should offer it. Sets of slides (plebeian song slides) especially made for the dissolving lantern (and the skillful operator) should be offered by the slide manufacturers. The construction of such a dissolving set, by slides additional to the usual set, and made at the same time, and added to the set when used for the dissolving lantern, will add to the interest of the show and the reputation of the slide maker; let the theater manager demand them and the demand will be met by the manufacturers.

Speed of Change. The easiest method of control which the operator has in a set of slides is the speed at which he throws over the dissolving lever. This speed controls largely the dissolving effect upon the screen. By carefully watching the matter of lever speed, the change from the old slide to the new one in many instances may be made pleasing or ludicrous.

Where the change between the two slides is in the figures only and the scene setting can be brought into alignment, a very slow change produces a pretty effect. Where the change is from a scenic view to a single object in detail, as from a woodland scene to a bouquet, either with or without the usual framed face, the slow change is pleasing. Entirely dissimilar views sometimes unite in unexpected combinations which are pleasing and which may be offered to the audience by the slow movement of the change lever.

Entirely dissimilar views sometimes unite in unexpected combinations which are ludicrous in the extreme; two moons in one sky, or a white horse and buggy upon a parlor sofa, are not commonly seen except upon the picture screen with a dissolving lantern and a thoughtless operator. In a case of this kind, make a swift change by a quick movement of the dissolving lever, or change the order of the slides in the set. In a lecture, the order of the slides can not be changed. In an illustrated song, the slides sometimes are so characterless and so meaningless, that the rearrangement of a few of them, or the omission of a few of them, is quite permissible.

THE MOTION-HEAD LANTERN

The lantern is not different, but its method of operation has a requirement additional to that of a lantern used for fixed slide projection only. The motion-picture film image being but one-tenth the area of the fixed slide, and the picture on the screen being required to be about the same size, the motion-picture film must have ten times the intensity of light to stand the increased magnification. An increase in light intensity is effected by putting the film in a more condensed portion of the cone of light coming from the condensers, but it remains a fact that fixed slide projection may be accomplished satisfactorily with a less brilliant arc than that required for the motion picture. To state it the other way about, the motion-picture arc must be a hotter arc than that actually required for fixed slides, and the motion-head lantern must furnish a stronger light.

Having the strong light for the motion picture, it is easy to use it for the fixed slides, and it is customary so to do. It is customary also to break announcement slides with the excessive and unnecessary heat. Take note that the motion-picture film is exposed to the heat of the arc for about one-fourteenth of one second, while the announcement slide is on the screen and exposed to the heat of the arc from ten seconds to a full minute or even more.

The motion-head lantern equipped with an auxiliary rheostat, or with an auxiliary switch for an adjustable rheostat, will save money by using less electric current and will save money also by requiring fewer new announcement slides to replace the slides broken by the unnecessary heat of the motion-head arc.

With direct current, fifteen amperes is sufficient current for the projection of a fixed lantern slide upon a picture screen less than fifteen feet wide; for the same screen the motion-picture projection should use thirty to forty amperes. With only alternating current supplied from the power mains, the currents used by the lamp will be greater, running to sixty amperes for the motion-picture arc, but the proportion will remain.

Auxiliary Rheostat. Two rheostats may be wired into the same lamp circuit, the first one of them as usual and the second one with a short-circuiting switch or shunting switch placed handy to the operator when standing at the projecting machine. The second rheostat being shorted by the switch, the first rheostat is adjusted to give the current required for the motion-head arc. The shorting switch then is opened and the second rheostat is adjusted (leaving the first as it was) so that the two together give a sufficient current for the projection of lantern slides, using probably not more than one-third and certainly not more than one-half the current required for the motion-head work. Thus adjusted, the motion head always is run with the shorting switch closed and the fixed slides always are projected with the shorting switch open.

The arrangement of circuits with two rheostats is shown in circuit diagram in Fig. 29. At the extreme left are shown the street mains of the electric circuit, appearing as two vertical lines *SM*. Branch wires pass from the street mains to the lamp *L* at the right and in this pair of branch wires or lamp leads are included first the main switch *MS* and then the two rheostats *R* and *AR*, the auxiliary rheostat *AR* being provided with a shorting switch *SS* whose blades are connected to the terminals of the auxiliary rheostat. In operating, the switch *SS* is closed and the rheostat *R* is adjusted for the motion arc; then *SS* is opened and the second rheostat *AR* is adjusted to cut the current down for the song slides, fixed slides always being shown with the switch *SS* open.

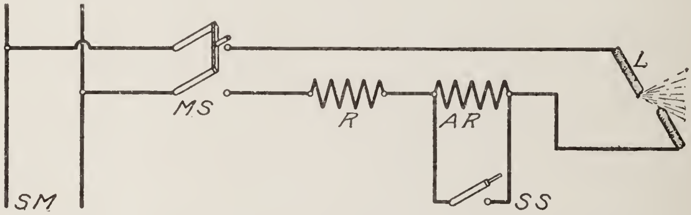


Fig. 29. Connections for a Single Lantern with Two Rheostats

Auxiliary Rheostat for the Double Lantern. When the double lantern is used for motion pictures and dissolving slides, it will be seen that the upper lantern never is used for the motion head. It will not require the adjustable-current feature. A wiring diagram for a double lantern for motion head and dissolving slides, equipped with the current-saving rheostats, is shown in Fig. 30.

At the left, Fig. 30, the vertical pair of lines represents the street mains for the electric-power circuit. From these street mains a pair of wires is taken to two double-pole knife switches, one switch for each of the two lanterns. From the lower knife switch the circuit extends to the right to the lamp of the lower lantern, passing through the two rheostats *R* and *AR*, and the shorting switch is connected to the terminals of the auxiliary rheostat *AR*, as it was in Fig. 29. With the upper lantern, however, it is necessary to balance the current against the lower lantern when the shorting switch *SS* is open. To show that balancing in the diagram, two rheostats are shown in the circuit of the upper lamp, but the shorting switch is not required, as the upper lamp is used for slides only. A single rheostat will be sufficient for the upper lamp if it is capable of being adjusted to a resistance to balance the two rheostats of the lower lamp.

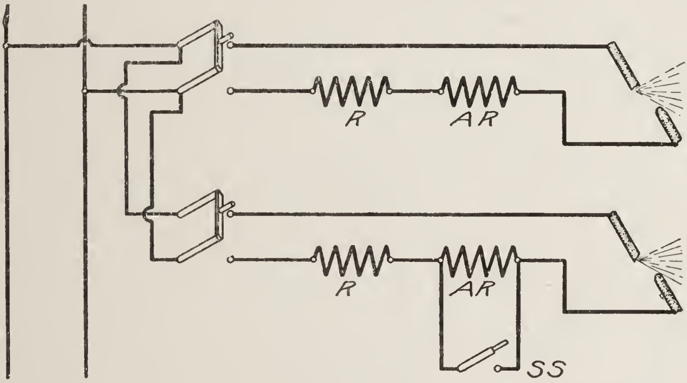


Fig. 30 Connections for a Dissolving Lantern with Two Rheostats

Auxiliary Switch. Another arrangement for saving current and condensers and also for improving the quality of the exhibition, by reducing the heat of the lamp for slides, is that of using both parts of an adjustable rheostat in the sense of the two rheostats shown in Figs. 29 and 30.

Fig. 31 shows an arrangement in a circuit diagram for a single lantern using two values of resistance from one adjustable rheostat, and Fig. 32 shows an arrangement of the same nature for the double or dissolving lantern when one of the lanterns is to be used for motion head also. In Fig. 31, the street mains are shown vertically at the left; from the street mains the lamp lead is taken to the knife switch on the power board, and from the knife switch through the adjustable rheostat to the lamphouse and lamp. The method of connecting the rheostat is the one usually used, carrying the circuit to the lamphouse through all of the wire of the rheostat and then short-circuiting as much of the rheostat wire as is not needed. The shorting may be done in the rheostat either by a movable handle, as indicated in Fig. 31, or by a short connecting wire between posts or terminals on the rheostat. This method of connecting a rheostat has the advantage of giving a continuous circuit through all of the wires of the rheostat in case the short-circuiting arm of the device makes a defective con-

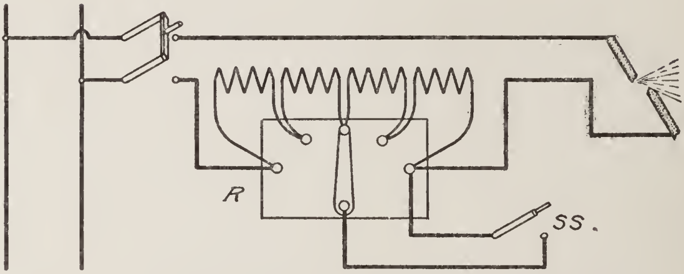


Fig. 31. Connections for an Adjustable Rheostat and Auxiliary Switch with a Single Lantern

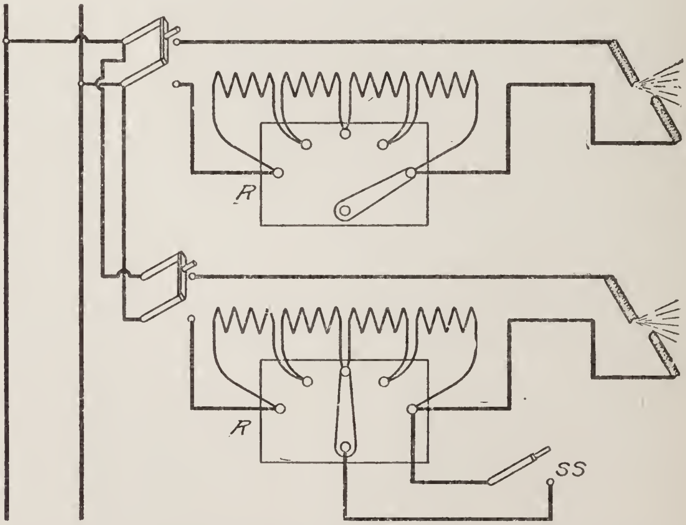


Fig. 32. Connections for an Adjustable Rheostat and Auxiliary Switch with a Dissolving Lantern

tact, or in case the short-circuiting bridging wire is accidentally broken or disturbed. Not only is the projecting possible in case of such an accident, but there is the further advantage that disastrous arcing will not occur at the rheostat because the break will be shunted by the rheostat wire. With this method of connection of the rheostat into the lamp circuit, either in the case of the arm type of device or of the bridging wire type, the short-circuiting conductor of the rheostat is cut and is taken by extension wires of sufficient size to carry the full current to the short-circuiting switch *SS* which is at the operator's hand as he stands at the projecting machine. By closing the shorting switch *SS*, the coils of the rheostat are short-circuited and the current has the full value intended for motion-head work according to the adjustment of the rheostat, but when the shorting switch *SS* is opened, then the rheostat has the short taken off of the coils which had been cut out, and the full resistance of the rheostat is effective upon the lamp circuit, cutting the current down to a proper amount suitable for use with slides without endangering them by excessive heat.

The arrangement for the double lantern is shown in circuit diagram in Fig. 32. The lower lantern is equipped exactly as is the lantern shown in diagram in Fig. 31, but the upper lantern has the full resistance value of the rheostat always in its circuit, thereby equaling the adjustment of the lower lantern when the shorting switch is open, no switch being used with the upper lantern. Only two rheostats are required for the lanterns, and they should have the same resistance that they may balance each other for the song slides and other dissolving pictures.

THE LENS

The projecting lens should be anastigmatic, rectilinear, and achromatic. It should reproduce upon the picture screen the image of the lantern slide with the least possible degree of distortion, or with a negligible amount of distortion of the picture.

Lens Corrections. The usual lens for stereopticon projection is the Petzval type, an achromatic, rectilinear lens of four glasses, the two glasses of the front end of the lens tube being cemented together and the two of the back end of the tube being held apart by a spacing ring. Fig. 33 shows the shape of the glasses used in this lens. The double end, with the two glasses and the spacing ring between, always should go next to the slide, and the single end toward the picture screen.

With the Petzval lens, and with all astigmatic lenses of any type, it is impossible to get a sharp focus over all of the picture screen at the same time. The peculiarity of the focus of the astigmatic lens is that the picture sometimes presents streaks radiating from a common point and at other times presents large arcs around a common point. The focus seems to be sharp only in a center spot or in a ring surrounding a center spot. In some slides the defects of the astigmatism of the lens can not be noticed, while in others it is prominent. Slides with sharp points of light show the defect more prominently than slides having only lines, while slides showing scenes without sharply cut features near the edges will not show the astigmatism at all. In any picture projected with the astigmatic lens the corners must be sacrificed to improve the central portion of the view, for the astigmatic lens usually is a cheap lens and lacks in angle of view as well as in the correction for astigmatism.

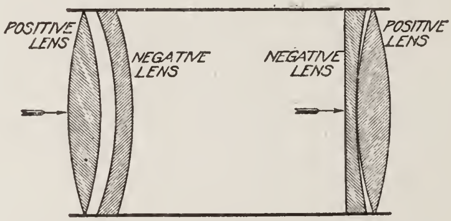


Fig. 33. Section Through the Glasses of a Projecting Lens of the Petzval Type

An achromatic lens is one which will project white light without making color fringes along every sharp edge between light and shadow in the picture. White light is composed of many colored rays, and a single piece of glass, such as a glass prism, will separate the colors. The cheapest form of lens also will separate the colors, as may be seen with a cheap reading glass which colors the edges of black letters upon a white sheet. The projection lens must keep the lines clear of colors. Do not blame the lens for coloring which is due to the arc being out of adjustment. Coloring in the pictures caused by lack of adjustment of the arc will color the whites of the picture in blotches, while a poor lens will give a clear white in the middle of a large white area but will color the edge where black meets white in a sharp line, particularly toward the margins of the picture.

A rectilinear lens is one which will project a straight line of the slide as a straight line in the picture on the screen. The straight line of the mask or edge of the picture of the slide is a line coming under this rule, and a rectilinear lens is required to give straight edges to the picture. Rectilinear lenses have their glasses separated into two groups, as shown in Fig. 33, for the Petzval form of lens, one group of glasses being mounted in the front end of the lens tube and the other in the back end, and each of the two groups having two glasses to give achromatic correction.

The next consideration in the projection lens is the angle of the cone of light which it will handle. This requirement rises from the fact that the slide is not always placed centrally with the axis of the lens. Its manifestation on the picture screen usually takes the form of dark corners at the two lower corners of the picture. When the axis of the lens is shifted to correct the corners, the sides of the picture become inclined toward each other, even with a rectilinear lens, and the "keystone" picture results. In addition to being achromatic, rectilinear, and anastigmatic, therefore, the projection lens should have a sufficiently wide angle to bring up the corners of the picture without giving the picture the keystone shape to such an extent as to be objectionable. Even the cheapest lenses for projection purposes are rectilinear and achromatic; anastigmatic and wide-angle lenses may be had if one wishes to pay for them.

Lenses for Given Requirements. To select a lens for the projection of lantern slides in a particular theater requires that the distance from the picture screen to the projection machine, called the "length of throw," be measured, and that note be taken of the offset distance of the projection machine, *i. e.*, the distance to the side or toward the ceiling from the line of the center of the picture on the screen.

If the distance from a horizontal line from the middle of the picture on the screen, measured from the lens to the line, is not greater than one foot for each ten feet of throw, it is likely that a good picture will be secured with a narrow angle lens. That is, for example, as follows: Where the screen is vertical, either upon a wall or on a drop curtain of a stage, the point of the middle of the picture probably will be slightly above the middle of the screen, because the top of the picture will be thrown to the top of the screen, the bottom of the picture being above the bottom of the screen. With the projection machine in the middle of the house at the rear, facing the screen, then the height of the middle of the picture on the screen may be compared with the height of the lens of the projection machine. Usually the lens of the projection machine is above the height of the middle of the picture on the screen. Now with a sixty-foot throw and the lens more than six feet higher than the middle of the picture, there will be a compromise between a sharp picture and a keystone picture unless a wide angle lens is obtained. With a throw of one hundred feet, the lens may be ten feet higher than the middle of the picture before the trouble becomes aggravated. With short throws from an elevated position in the room a very wide angle of lens should be obtained if possible. The feature of the lens angle is illustrated in a diagram in connection with the focusing of the picture upon the screen. The requirement of greatest prominence, and sometimes the only requirement considered in selecting a lens, is the length of the lens focus.

Length of Lens Focus. For the purposes of the projecting stereopticon, the length of focus of a lens may be defined as *the distance from the center of the lens tube to the lantern slide when the slide is in focus upon the screen;* but the real focal length is just a little shorter, and the focal length is determined by the length of throw and the size of the picture required upon the screen, the lens being properly adjusted to the slide distance afterward.

The focal length of a lens may be measured also by focusing the image of the sun upon a card and measuring from the middle of the lens to the card, or by focusing the light of a distant window upon a white card until the lines of the window are sharp and then measuring the distance from the center of the lens tube to the card. The lens length required for lantern slides for a given theater is most easily obtained from a lens table.

Lens Table. Table I gives the size of the picture upon the screen for different lengths of lenses and different lengths of throw, when lantern slides are projected. At the left is given the lengths of the different lenses considered, from 5 inches to 24 inches. The columns at the right of the first column are arranged each for a

TABLE I

Size of Screen Image When Lantern-Slides Are Projected

Size of Mat Opening 2¾ by 3 Inches

Equiv. Focal Length of Lens Inches	Length of Throw												
	15 ft.	20 ft.	25 ft.	30 ft.	35 ft.	40 ft.	45 ft.	50 ft.	60 ft.	70 ft.	80 ft.	90 ft.	100 ft.
5	8.0	10.8	13.5	16.3	19.0								
	8.8	11.8	14.8	17.8	20.8								
5½	7.3	9.8	12.3	14.8	17.3	19.8							
	7.9	10.7	13.4	16.1	18.8	21.6							
6	6.6	8.9	11.2	13.5	15.8	18.1	20.4						
	7.3	9.8	12.3	14.8	17.3	19.8	22.3						
6½	6.1	8.2	10.4	12.5	14.6	16.7	18.8						
	6.7	9.0	11.3	13.6	15.9	18.2	20.5						
7	5.7	7.6	9.6	11.6	13.5	15.5	17.5	19.4					
	6.2	8.3	10.5	12.6	14.8	16.9	19.0	21.2					
7½	5.3	7.1	8.9	10.8	12.6	14.4	16.3	18.1					
	5.8	7.8	9.8	11.8	13.8	15.8	17.8	19.8					
8		6.6	8.4	10.1	11.8	13.5	15.2	17.0	20.4				
		7.3	9.1	11.0	12.9	14.8	16.6	18.5	22.3				
8½		6.2	7.9	9.5	11.1	12.7	14.3	16.0	19.2				
		6.8	8.6	10.3	12.1	13.9	15.6	17.4	20.9				
9		5.9	7.4	8.9	10.5	12.0	13.5	15.1	18.1	21.1			
		6.4	8.1	9.8	11.4	13.1	14.8	16.4	19.8	23.1			
9½		5.6	7.0	8.5	9.9	11.4	12.8	14.2	17.1	20.0			
		6.1	7.6	9.2	10.8	12.4	14.0	15.5	18.7	21.9			
10		5.3	6.6	8.0	9.4	10.8	12.2	13.5	16.3	19.0	21.8		
		5.8	7.3	8.8	10.3	11.8	13.3	14.8	17.8	20.8	23.8		
12			5.5	6.6	7.8	8.9	10.1	11.2	13.5	15.8	18.1	20.4	
			6.0	7.3	8.5	9.8	11.0	12.3	14.8	17.3	19.8	22.3	
14				5.6	6.6	7.6	8.6	9.6	11.6	13.5	15.5	17.5	19.4
				6.2	7.3	8.3	9.4	10.5	12.6	14.8	16.9	19.0	21.2
16					5.8	6.6	7.5	8.4	10.1	11.8	13.5	15.2	17.0
					6.3	7.3	8.2	9.1	11.0	12.9	14.8	16.6	18.5
18					5.1	5.9	6.6	7.4	8.9	10.5	12.0	13.5	15.1
					5.6	6.4	7.3	8.1	9.8	11.4	13.1	14.8	16.4
20						5.3	6.0	6.6	8.0	9.4	10.8	12.2	13.5
						5.8	6.5	7.3	8.8	10.3	11.8	13.3	14.8
22							5.4	6.0	7.3	8.5	9.8	11.0	12.3
							5.9	6.6	7.9	9.3	10.7	12.0	13.4
24								5.5	6.6	7.8	8.9	10.1	11.2
								6.0	7.3	8.5	9.8	11.0	12.3

different length of throw, the length of throw being mentioned at the top of the column.

With each length of lens there are two figures for each length of throw, viz, the height and the width of the picture upon the screen.

This table works "both ways" in that it tells the size of picture when the lens length and the screen distance are known in advance, or it will tell the lens length required to give a picture of a desired size when the screen distance and the picture size are known. The following examples show the use of the table:

(1) With a house in which the screen is to be forty feet from the projection machine, it is desired to project a lantern-slide picture *about* 9 feet square. In the table, the column is taken which has "40 ft." at its top, being the sixth of the narrow columns, counting from the left, and in this column the pairs of figures are examined until a suitable pair is found; in this column there is a pair of figures, 8.9 and 9.8, and at the left, in the first column of the table is the figure, 12. The meaning is that a 12-inch lens with the 40-ft. throw of the theater will give a picture (from a lantern slide with a 2¾″ × 3″ opening in the mask, the usual song-slide size), which will measure upon the screen a little less than 9 feet in height and very nearly 10 feet in width.

(2) An operator is obliged to project lantern slides in a room where for convenience in placing his projector it must be 25 feet from the picture screen. He has three lenses for the lantern, 6-inch, 8-inch, and 10-inch. Which shall he use to get proper results at first trial, and not reveal a lack of skill and experience by making experiments before an audience? In the 25-foot column and opposite the figure 6 of the first column are found the figures, 11.2 and 12.3; in the same 25-ft. column and opposite the figure 8 in the first column are found the figures, 8.4 and 9.1; in the same 25-ft. column and opposite the figure 10 of the first column are found the figures, 6.6 and 7.3; the meaning is that the 6-inch lens will give a picture about 11 ft. × 12 ft.; the 8-inch lens will give a picture about 8 ft. × 9 ft.; and the 10-inch lens will give a picture about 6 ft. × 7 ft. The operator then measures or estimates the size of the screen and picks the lens which will give the largest picture that the screen will hold.

(3) To change the size of the picture, the table may be worked both ways at once, as it were, taking the results by an inspection of the table by differences, since the object is to make a difference in the size of the picture now being projected by making a difference in the length of the lens used. With a 45-ft. throw and a 9-inch lens, the picture is too large. Going into the table to find the size of picture, it is found to be 14.8 ft. wide, or about 14 ft. 9½ in. Now taking the table to find the size of lens for a smaller picture, the 9½-inch lens gives a picture 14 ft. wide; thus, by the table, a difference of half an inch in the length of the lens makes a difference of 9½ inches in the width of the picture. By actual measurement on the screen, the projected picture with the old lens may be several inches different from the size given in the table, but the difference in the table for the difference in the lenses will hold good, and is the safest way to figure for a new lens.

To obtain the focal length of a lens accurately, put it in a photographic camera and focus upon any object, say a strip of paper three inches long pasted upon a window pane, until the image on the ground glass is exactly the size of the object itself. Then the focal length of the lens is one-quarter of the distance from the ground glass to the object itself.

Estimating Lens Length. In estimating the lens length to fill a given screen with a given throw, a margin should be left upon the screen all around the picture. Many lantern slide masks are not exactly centered with reference to the position of the opening of the mask and the edges of the glass plates. Many slides, and particularly announcement slides, will exceed the usual standard limit of $2\frac{3}{4} \times 3$ inches, running even to 3 inches in height and $3\frac{1}{2}$ inches in width. A single slide which runs over the edge of the screen in an evening's exhibition will discredit the theater. It does not create in the minds of the audience the proper thought that the slide maker has been in error, that the slide is abnormal and too large for the screen, but creates instead the thought that the screen is too small for the slide or that the operator's skill is too small for his job, and that the theater is a small caliber place in general.

Calculating Lens Data Without the Table. The rule used is the "rule of three" or the rule of simple proportion among four quantities; three being known, the fourth always may be found by simple arithmetic.

For practical purposes, the rule may be taken, *that the slide is to the picture as the focal length is to the throw.* That is, the proportion between the size of the mask window in the slide and the picture as projected upon the screen is the same as the proportion between the focal length of the projecting lens and the distance of throw, lens to screen.

To make this rule available for arithmetic, it is placed in the form

$$\text{Slide} : \text{Picture} :: \text{Focal length} : \text{Throw}$$

from which the equation is taken

$$\text{Focal length} \times \text{Picture size} = \text{Slide size} \times \text{Throw}$$

This equation works out for the height or width of the picture, according as the height or width of the slide is taken. Taking any three of these measurements as known, the remaining measurement may be obtained, as follows:

For Lens Length. Multiply together the slide size (say 3 inches wide) and the length of throw measured from the lens to the middle of the picture screen, taking both in *inches.* The result is to be divided by the width of picture which it is desired to project upon the screen, also taken in *inches,* and the final answer thus found will be the length of focus of the lens, in inches, which will be needed. All measurements must be reduced to inches before multiplying and dividing.

In calculating for the projection of lantern slides upon a screen used also for motion pictures, it must be remembered that the shape of the lantern-slide picture is different from that of the motion picture; if the screen takes the shape of the motion picture, the lantern-slide picture cannot be made to fill it, and should be calculated for height, not for width. With a motion picture 9 ft. × 12 ft., the lantern-slide picture will be 9 ft. × 10 ft. or 10 ft. × 11 ft. to secure the most pleasing effect in changing from one to the other quickly.

Example. *Calculating lens length.* For a 30-ft. throw, it is desired to project a picture 10 ft. wide. 30 ft. is 360 inches and 10 ft. is 120 inches. The slide is 3 inches wide. 3 × 360 (slide size multiplied by throw) gives 1080; then 1080 ÷ 120 (the first result divided by the picture size desired) gives as an answer, 9, meaning that a lens of 9-inch focal length will give the desired size of picture at that throw. The picture will be slightly smaller, because the distance from the slide to the lens is slightly greater always than the actual focal length of the lens. The lens table gives the size of picture with a 9-inch lens at 30 ft. as 9.8 ft., or 9 ft. 9½ in., or about 2½ in. smaller than the simple arithmetical calculation.

For Picture Size. Multiply together the slide size in inches and the length of throw in inches, then divide by the focal length of the lens in inches. The picture projected will be only a trifle smaller than the answer obtained.

Example. *Calculating size of picture with any lens.* With a throw of 35 ft. and a 10-in. lens, reduce the throw to inches, 420 inches, multiply by the width of the slide. 3 × 420 (slide size multiplied by throw in inches) gives 1260; then 1260 ÷ 10 (the first result divided by the length of the lens in inches) gives 12 ft. 6 in. Here the table gives 12.3 ft., or 12 ft. 3½ in.

For Slide Size. It might seem that the operator would not have this calculation to make, since as an operator he would not

SCENE FROM "THE LAST EDICT OF FRANCIS II," BY ECLIPSE
An Historical Drama Vividly Portraying the Character of Catherine de Medici
Courtesy of the *Kleine Optical Co., Chicago*

have to make slides. It is involved in the making of emergency slides where the operator wishes to cut the mask with the largest opening which can be projected upon his screen. It is involved in the selection of announcement slides, which have mask windows of different sizes, many of them too large for the operator's picture screen. By this calculation, the operator may determine the largest slide-mask window which his screen will take with the lens he is using, and can select announcement slides which fall within the limiting dimensions.

Multiply together the focal length of the lens and the size of the picture projected or which it is desired to project, in inches. Divide the result by the throw in inches. The final answer will be the dimension which in the slide window will fill the screen as desired when projected. If the width of picture has been taken in the calculation, the result will give the width of the slide-mask window. If height of the picture has been taken in the calculation, the result will give the height of the slide mask window.

Example. *Calculating slide-mask window.* With a throw of 30 ft. and with a 10-in. lens, the screen is 8 ft. 9 in. by 10 ft. 6 in. By the table the 10-inch lens gives a picture 8 ft. by 8.8 ft., or 8 ft. by 8. ft. $9\frac{1}{2}$ in. It is desired to fill the screen within a few inches, to project a picture, say, 8 ft. 6 in. by 10 ft. 3 in.

For the width, 10 × 123 (the focal length of the lens in inches multiplied by the desired width of the picture in inches) gives 1230; 1230 ÷ 360 (the first result divided by the throw in inches) gives $3\frac{5}{12}$ as the final answer. The slide-mask window may be about $3\frac{1}{2}$ inches wide.

For the height, 10 × 102 (the focal length of the lens in inches multiplied by the desired height of the picture in inches) gives 1020; 1020 ÷ 360 (the first result divided by the throw in inches) gives $2\frac{5}{6}$ as the final answer. The slide mask may be about $2\frac{3}{4}$ by $3\frac{1}{2}$ inches to fill the screen.

For Length cf Throw. This calculation is required when the operator, having but one lens available, must determine how far from the screen to place his projection machine to secure a picture of the desired size. Aside from private exhibitions, in parlors or improvised halls, it has little value.

Multiply the focal length of the lens by the desired picture size and divide by the slide size, taking all dimensions in inches. The answer will be the distance in inches from projection machine to screen, or length of throw.

Example. *Calculation of length of throw.* The operator has but a 6-inch lens, and the screen provided is 5 × 6 ft. Taking 5 ft. 6 in. as the widest picture safe for the size of screen, 6 × 66 (focal length in inches multiplied by picture width in inches) gives 396; 396 ÷ 3 (first result divided by width of slide mask window in inches) gives 132 inches, or 11 feet as the length of throw.

If an 8-inch lens were available, the calculation would give 8 × 66 ÷ 3, equal to 14 ft. 8 in. as the length of throw. Such small dimensions as these, met only in private exhibitions, will not be found in any table, and when such dimensions are encountered the rule for calculation without the table becomes of use.

Accurate Calculations. The distance from the lens to the lantern slide always is a little greater than the focal length of the lens. This difference has been omitted from the foregoing rules because the variation is small in the final results and within the variations of probable error in taking the measurements in the first place.

For greater accuracy, the length of throw should be taken along the axis of the projection lens or of the optical system. Let T equal this length of throw, lens to screen, F equal equivalent focal length of the lens, S the slide-mask window dimension, and P the corresponding picture dimension, all dimensions being taken in inches or in the same unit.

By the law of optics which may be called the "Law of the Relation of Image Sizes,"

$$S : P :: D : T$$

$$ST = PD \qquad (1)$$

By the law of optics known as the "Law of Conjugate Foci,"

$$D-F : F :: F : T-F$$

$$F^2 = (D-F)\,(T-F) \qquad (2)$$

These two equations include five variables, S, P, D, T, and F, of which the value of the variable D never is required in practice. Of the remaining four variables, S, P, T, and F, when any three of the four are taken as known or assumed or desired, the remaining one may be determined accurately by the operations of simple algebra.

As the final focus is obtained by *shifting the position of the lens,* and as the position of the lens depends upon its focal length, which focal length has not been determined as yet at the time of measuring for the dimensions for the calculation, the only distance which can be measured along the axis of the optical system is the distance from the slide to the screen. Let H equal the distance from the slide to the screen, then, by the premises of the problem,

$$D + T = H \tag{3}$$

From the three equations (1), (2), and (3), any one of the four dimensions, S, P, H, and F, may be determined accurately, when the remaining three are known or assumed or desired.

Lens Construction and Adjustments. Projection lenses are made up of a number of glasses, at least two, front and back, the focal length of each glass being greater than the resulting focal length of the combination. If still another glass were added to the combination, the focal length would be reduced as a result of the addition. Lenses of small curvature in clip-cap holders, similar to that shown in Fig. 34, may be used to change the size of pictures slightly and at a very small cost. The size of a picture may be decreased by ten per cent in this way, and by the use of a "negative lens" similarly mounted in a cap, the size of the picture may be increased slightly.

Care of Lenses. Every day, wipe the outside surface of the lenses with a soft camel's hair brush, without taking the lenses from the tube or the tube from the holder. The hair of the brush should be an inch long, without any stiffness whatever. The type of brush known as "camel's hair pencil," consisting of a bunch of camel's hair drawn into a quill, is suitable, a large size of pencil (yet smaller than a lead pencil) being chosen. In wiping the surface of the lens, the brush should not be bent to rub the lens with the quill or handle, but to stroke the glass with the hair of the brush to sweep away dust grains or fine particles of lint which may have floated to the surface of the lens. Keep the brush in an envelope, such as is used for mailing letters, when not in use that it may not collect dust. The movement of the brush is to sweep away dust grains, not to polish the glass or clean it of finger marks. If the glass gets finger marks, more violent treat-

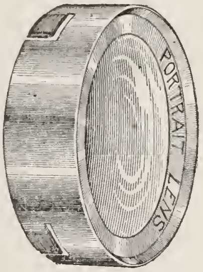


Fig. 34. Clip-Cap Lens, or Auxiliary Lens

ment, say with an extra soft chamois, is necessary to wipe them away; keep the chamois also in an envelope away from dust.

With time—and it is a matter of months rather than of days—lenses will acquire a gray film upon their inside surfaces. This may be removed by washing with alcohol and wiping with a dry, soft cotton rag, then polishing with soft chamois. The alcohol should be $\frac{1}{4}$ alcohol and $\frac{3}{4}$ water, as the pure alcohol will dry upon the surface of the lens so quickly that it will leave the surface as bad as before. In taking out the lenses, lay them carefully and in order upon the table where you are working, then take them up one only at a time, cleaning it carefully and putting it back in its proper position, so that there will be no possibility of a mix-up when they are put back in the tube. Once a year is often enough.

FOCUSING

The general subject of focusing is involved throughout the adjustment of the optical system of the lantern, and focusing the light has particularly to do with the adjustment of the lamp with reference to the position of the arc relative to the condensers. The relation of the projected image to the screen upon which it is to be viewed now will be considered.

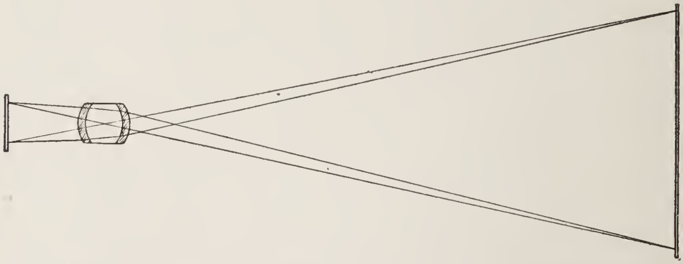


Fig. 35. Diagram of a Slide in Focus upon the Picture Screen

The final focus is attained by moving the stereo lens slightly forward or backward in its holder to bring the converging rays of light into focus upon the picture screen. From each point of the lantern slide a bundle of rays passes to the lens, striking all over the back surface of the lens, being bent within the lens and passing out of it practically from all over the surface of the front glass; then the bundle begins to draw together and finally converges into practically a single point, or very small spot of light. The distance of this spot from the lens is dependent upon the distance of the lens from the slide, and by proper adjustment of the position of the lens, the sharp focus of the bundle of rays may be made to occur upon the surface of the picture screen. This gives the condition illustrated in Fig. 35. The lantern slide is at the left, the lens near it, and the picture screen is at the extreme right. The bundles of rays from the lens meet upon the screen surface.

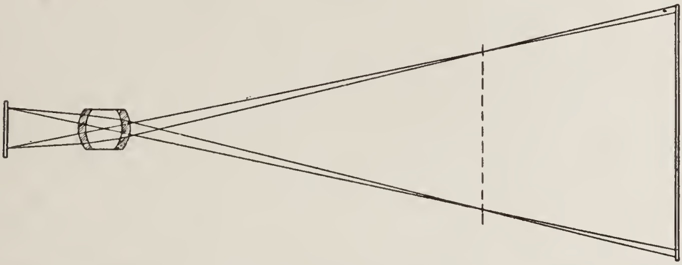


Fig. 36. Diagram of a Slide Out of Focus Upon the Picture Screen. Lens too far from Slide

For illustration of the out-of-focus conditions, Fig. 36 is given, illustrating the condition when the lens is too far from the lantern slide, and Fig. 37 is given, illustrating the condition when the lens is too close to the slide.

In Fig. 36, the converging bundles of rays leaving the lens cross before they get to the picture screen and spread again, reaching the screen slightly spread out, the different adjacent bundles blending into each other and producing the blurred effect upon the screen well known as a slide out of focus. The true focus of the image is at the dotted line drawn across the rays at the point of crossing of

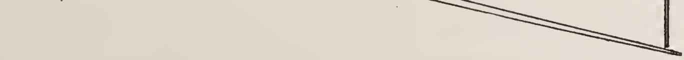


Fig. 37. Diagram of a Slide Out of Focus Upon the Picture Screen. Lens too close to Slide

each of the bundles of light. This would be the proper position of focus for the lens if the screen were nearer, and the image is correspondingly smaller, in proportion to the lesser distance of the screen from the lens. This diagram shows clearly how the nearer screen or shorter "length of throw" gives a smaller picture upon the screen for the same lens, or same focal length of lens, as shown by the lens table. The "focal plane" or "image plane" represented at the dotted line of Fig. 36 may be moved forward toward the picture screen at the right of the figure by moving the lens back toward the lantern slide.

In Fig. 37, the lens is shown moved too far toward the slide. The converging bundles of rays now do not meet before they reach the screen, nor even at the screen, so that the result is a blur in the projected image, as before; as a matter of fact the rays would meet far to the right of the diagram, producing a very large picture upon a more distant screen.

The best adjustment for focus is attained only by experimental adjustment, moving the lens forward until it is just a little too far, then moving it backward until it is just a little too near, then taking a position between. With a cheap lens, sharp focus may not be obtained all over the field of the picture screen at once, because of the feature of curvature of field, or curvature of the image surface.

Curvature of Image. The surface, or the imaginary surface, upon which the image is brought into focus has been called, as quoted, the "focal plane" or "image plane" because it ought to be a plane or flat surface. To make it so, or even approximately so, requires specially constructed lenses for projection, involving usually a greater number of glasses in the lens tube and a correspondingly greater amount of labor and skill in manufacture and correspondingly higher prices to the purchaser of the lens.

Curvature of the image is illustrated in diagram in Fig. 38; the slide is represented at *SL* with its surface flat, as it always is; the lens is shown at *O*, and the image is shown at *I* in a curved line. This diagram represents a sectional view through the center of the slide, lens, and image, taking a vertical section by cutting the whole theater, as it were, into halves. The shape of the image at *I* is spherical, or saucer-shaped, with the edges of the saucer bending toward the projecting operator and the center of the saucer bent back toward the middle of the picture screen.

If the lens be adjusted to bring the bottom of the saucer-shaped image to the surface of the screen, there will be had a very sharp focus in the middle of the screen, with gradual fading away of detail toward the edges of the screen, the corners being worst of all. By bringing the lens slightly nearer the slide, the middle of the image or bottom of the saucer of the image is, theoretically, pushed back through the screen, giving a slight blur in the exact middle of the picture, surrounded by a broad band or ring of sharply focused image, then fading slightly again toward the corners. This is the best condition of focus where the effect of curvature is manifested in the lens. The condition of adjustment with the center of the picture slightly beyond the picture screen is illustrated also in Fig. 38, where the straight line *PS* represents the surface of the picture screen and the curved line *I* represents the curved line of the cut through the saucer-like image from the uncorrected lens *O*.

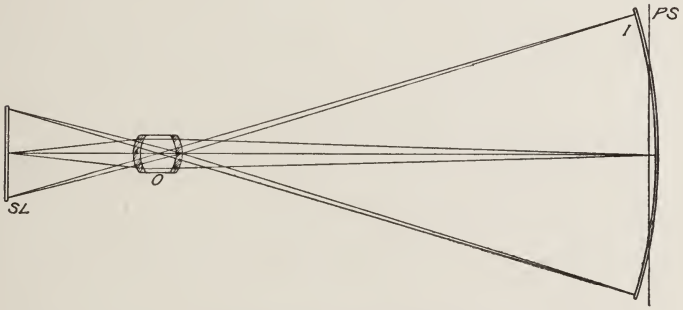


Fig. 38. Diagram Showing the Curved Image Surface of a Picture Projected by an Uncorrected Lens

Remedy for Curvature. The only remedy for curvature of image is the purchase of a new and a better, more expensive lens. Such lenses are advertised as having a "flat field." The image surface of such a lens will be sufficiently nearly flat to improve the picture beyond the condition shown in Fig. 36, bringing both center and corners into focus at the same time when the picture screen *PS* is parallel to the slide *SL*.

Inclined Optical Axis. Very few theaters offer the advantage assumed in Fig. 38, that the center of the lens is opposite the center of the picture screen. Sometimes it is at the side of the center, sometimes it is far above the center, sometimes both.

In Fig. 39, the projection lens is illustrated as being placed at about the level of the top of the picture screen, a condition met in large theaters where the pictures are projected from the upper balcony, but not usual in small motion-picture theaters. The first

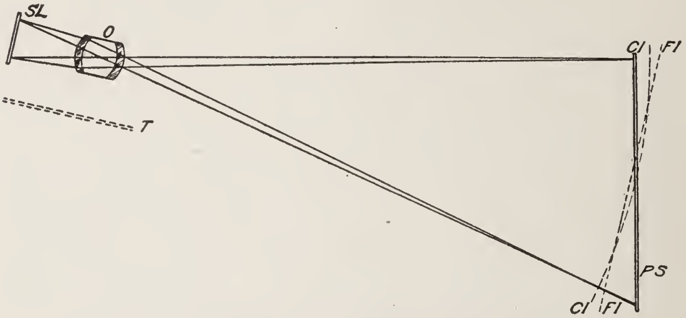


Fig. 39. Diagram of the Inclined Optical Axis

thought, when the ray of light from the lantern is thrown toward the screen and found to strike it near the ceiling, is to tip the whole projecting machine, table and lantern together, to make the center of the beam of light strike centrally on the screen. This is the condition taken in Fig. 39 for illustration of the inclined optical axis. Its results are shown in Figs. 39, 40, and 41.

At the extreme right of Fig. 39 is shown the vertical picture screen, and at the extreme left is shown the projection table top, slide, and lens. The table top is represented by the dotted parallel lines at *T*, showing its inclination. A little tilt can be endured, but the degree shown in the diagram would be fatal to good pictures.

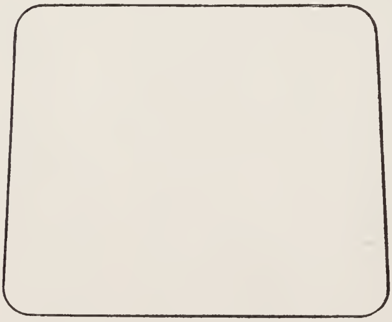


Fig. 40. Keystone Picture with Vertical Inclination

The slide *SL* in the slide carrier remains perpendicular to the table top *T* and, therefore, is tilted with reference to the picture screen *PS*. The lens *O* is parallel to the table top *T* and perpendicular to the surface of the slide *SL;* no advantage would be gained by having it otherwise.

The curved image surface is represented by the curved line

CI-CI extending in a curved line with its center opposite the lens *O*, but because of the inclination of the projection machine the curved image surface cuts the picture screen in but one place, instead of cutting it in two places as it did in Fig. 36. The defect of curvature of image surface, therefore, will be found to be made more objectionable when the operator is obliged to tilt his projecting table top. Nor will the substitution of a "flat-field" lens correct the trouble altogether. The image plane of a flat-field lens is approximately a flat surface at right angles to the axis of the lens. Such a surface is represented by the straight line *FI-FI* for the flat image in Fig. 39, but this flat image also cuts the surface of the picture screen *PS* in but one place and, therefore, will give but a band of sharp focus across the picture, the focus fading into blur slowly in either direction, upward or downward in the picture.

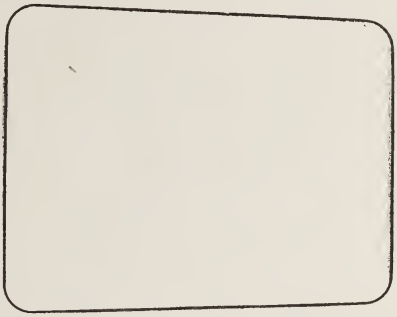


Fig. 41. Keystone Picture with Horizontal Inclination

The Keystone Picture. Further difficulties are found in the shape of the projected picture upon the screen. If the projection station is above the center of the screen, and the table top and the lantern are tilted downwardly, as shown in Fig. 39, the bottom of the picture screen will be farther from the lens than the top of the screen. As will be noted from Figs. 35, 36, and 37, the farther the distance from the lens to the screen, the larger will be the picture upon the screen; hence, as the bottom of the screen in Fig. 39 is farther from the lens than the top of the screen, the picture thrown upon the screen will be *larger at the bottom than at the top.* This effect is shown in Fig. 40. The top and bottom edges of this figure are parallel but the sides are not. It is the shape of the "keystone" picture, the picture which results when the optical axis of the projecting machine is inclined, being tipped downward.

When the projection machine is placed at the side of the room, thereby bringing it down sometimes to the level of the middle of the screen, the picture becomes distorted in its top and bottom lines, appearing as shown in Fig. 41, a shape more objectionable than that of Fig. 40.

Remedy for the Keystone Picture. In the correction of faults such as this, the good operator proves his superiority over the poorer one. The keystone effect may be entirely corrected for small angles by setting the lantern slide eccentric to the lens (it is more accurate to state that the lens is set eccentrically to the lantern slide) and may be corrected for still greater angles by the eccentric slide in conjunction with a good flat-field lens.

The setting of the eccentric slide is shown in diagram in Fig. 42. In this figure, the lens *O* is above the level of the center of the picture screen *PS*, about half-way between the middle line and the top line. The table top *T* is brought back to the horizontal position, the slide *SL* is vertical to the table top and is parallel to the picture screen, both the picture screen and the slide being vertical. The lens *O* is horizontal, parallel to the table top and at right angles to the slide and the screen, but it is dropped below the level of the center of the slide *SL,* so that a straight line from the upper edge of the mask window in the slide will pass through the center of the lens to the bottom of the picture in its desired position on the screen. The slide *SL* thus is not in the center of the lens (is "eccentric" to the lens) and the projected image is accordingly displaced, the slide being slightly above the lens in the lantern and the image being much below the lens on the screen.

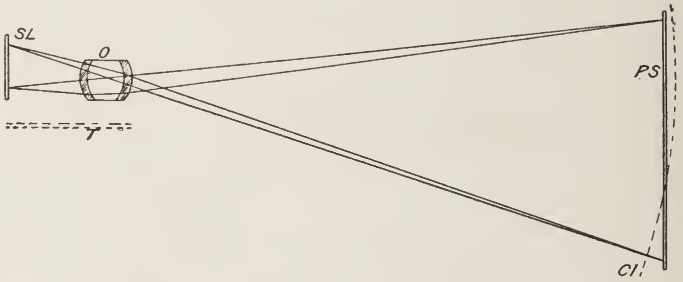


Fig. 42. Diagram of the Eccentric Slide

With reference to keystone distortion: The bottom of the picture is farther from the lens, as it was in Fig. 39, but the top of the lantern slide also is farther from the lens than the bottom of the slide. The foot of the slide is farther from the lens center compared with the head of the slide in just the same proportion that the foot of the picture screen is farther from the lens center compared with the head of the picture screen. As the size of the projected picture is wholly a matter of proportional distances, the size of the picture may be worked out by arithmetic to prove that the shape of the picture is correct, or more simply it may be tried on the picture screen with the lantern. With reference to focus: The curved image of the lens is represented in Fig. 42 by the curved line *CI*, and it crosses the picture screen *PS* in only one place, just as it did in Fig. 39. While the focus of the cheap lens with the curved image has not been improved, neither has it been made worse. With the flat-field lens, however, the flat-image surface will be straightened up when the projection table and slide and lens are made level, so that the flat image now will be parallel to the picture screen, and the entire picture will be in focus, top and bottom, center and corners.

Lens Angle. With reference to the direction of the rays of light passing through the lens in Fig. 42, it may be noticed that from the foot of the inverted slide, the upper edge of the slide in the diagram, the rays of light enter the lens *O* at a greater angle than they enter the lens of Fig. 39. Some lenses will accommodate a wider angle of light rays than others. The "wide-angle" lenses are either larger in the barrel diameter or shorter in barrel length, as compared with a cheaper lens of the same focal length which is able to care for only the narrower angles of light. The length of focus can not be determined by looking at a lens other than by testing its ability to bring light rays to a focus, but, knowing its length of focus, the angle which it will cover may be judged by its shape, the shorter length of barrel almost invariably giving the wider angle and giving greater power to cover the lower corners of the picture on the screen when the slide is set off the center of the lens. In photographic lenses, a lens of 6-inch focal length usually is used to cover a 4×5-inch plate, but a 6-inch lens may be made which will give an image all over an 8×10-inch plate, four times the area. The same difference can be found in projection lenses. If the lower corners of the picture on the screen show dark, you require a new lens of shorter barrel and of the same focal length, or you will have to tip the table a little and endure the keystone effect or correct it by a slide-holder keystone mask.

Two diagrams comparing the work of a narrow-angle lens and a wide-angle lens are shown in Figs. 43 and 44. At the left of each diagram is shown the lantern slide to be projected. It is seen that the lens of Fig. 43 has sufficient angle to project the slide if the slide is placed centrally within the solid lines representing the limits of the rays of light, but that if the slide is placed eccentrically above the center of the lens, as shown, the rays of light must pass as indicated in dotted lines, and the lens will be unable to do the work. In Fig. 44, however, the slide as placed eccentrically still falls within the working angle of the lens and the wide-angle feature of the lens thus permits that placing of the slide with satisfactory projection.

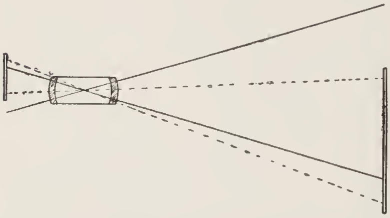


Fig. 43. Diagram of the Eccentric Slide with a Narrow-Angle Lens

Do not believe a salesman who tells you that "a lens is a lens and that is all there is to it." Get another salesman. There are differences in lenses. The working angle of the lens and the flatness of field or image are the two points in which all the cheaper lenses and some of the higher priced lenses will be found lacking. When the conditions of the theater force you to set the lens off the center of the slide, both flatness and wider angle will be needed for a good projection. Otherwise, the wider angle is a needless expense.

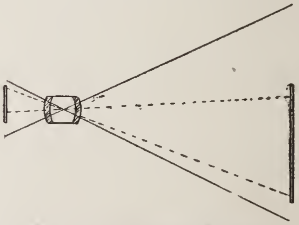


Fig. 44. Diagram of the Eccentric Slide with a Wide-Angle Lens

Inclined Screen. To reduce distortion in the picture with a lens of narrow angle, the screen may be inclined slightly, as shown in Fig. 45. This brings the optical system back to the fundamental condition of Fig. 1 and of Fig. 35. The inclined screen is objectionable to the spectator because of the difference in distance from the eye to the top and to the bottom of the screen, and this difference will itself bring in the keystone effect to the spectator's vision, even though the picture upon the screen be perfectly rectilinear.

All of the remedies for distortion may be used at once, inclining the screen a little, tipping the table a little, and setting the lens off center a little, including also the keystone mask.

The Keystone Mask. The keystone effect of Fig. 40 may be compensated for, so far as the edges of the picture are concerned, by providing the slide holder with a keystone mask for the window through which the slide is projected, the edges of the mask being a little smaller than the mask of the slide. Measure the angle of inclination of the sides of the picture on the screen and make the sides of the mask have the same angle of inclination. The top and the bottom lines of the mask are parallel if the picture on the screen is true in that detail. The mask now is placed in the slide-carrier window with the narrow edge up; the lens magnifies the upper edge of the mask because of the greater distance to the picture screen, and the keystone mask throws a rectilinear field of light upon the screen. Two masks will be needed, one for each end of the slide carrier, or one for each lantern of a dissolver. A single mask for the fixed window of the slide holder would be too far out of focus to give good service. The keystone mask will not correct the distortion of the image itself, but only correct the margins of the projected picture. With lantern slides of varying sizes, only those larger than the keystone mask will be corrected, and those of course are corrected by the cutting off of a portion of the edge of the picture as seen in the mask window of the slide itself. With the motion head, where all images for projection are of uniform size, the keystone mask becomes more practical. Greater skill is required in fitting it, because of its smaller size.

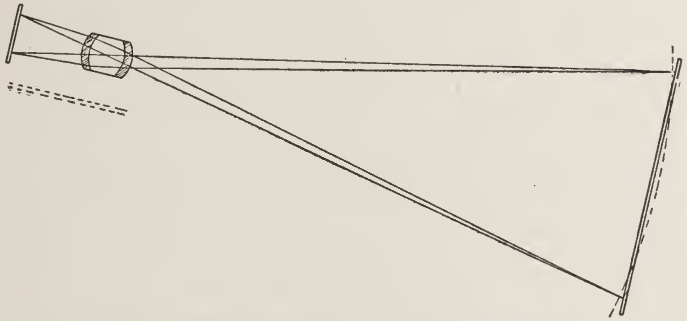


Fig. 45. Diagram Showing the Inclined Picture Screen

LANTERN SLIDES

Announcement Slides. Commercial announcement slides very frequently are over-sized. In selecting them, care should be taken to avoid getting a slide which will project a picture or field larger than the screen.

Emergency Slides. The quickest emergency slide is made of two cover glasses, a slip of draftsman's tracing paper or tracing linen, India ink, and a binding strip or piece of gummed paper. The mucilage edge of an envelope flap is always available for gummed paper when nothing else can be had. A lantern-slide mask or window is desirable, but not necessary. Write with a fine pen upon the tracing paper or linen, place between the glasses, stick together with the gummed paper and put it into the lantern. If cover glasses are not at hand, the binding strip may be slit on a couple of song or announcement slides and the cover glasses thus obtained. This slide is improved by turning the tracing paper over and tracing the writing on both sides of the sheet before putting it into the cover glasses.

Cover glasses, masks, and binding strips should be at hand at all times for the repair of slides. Add to this equipment a bottle of Higgins Waterproof Ink and a supply of crowquill pens and tracing paper and the emergency slide-making set is complete. Cut the tracing paper to lantern-slide size, place a mask upon each small sheet, and run a sharp pencil around the window of the mask. When writing, keep the words inside the pencil line and parallel to the edge of the sheet.

For a typewritten slide with this outfit, cut a larger sheet of tracing paper, place a mask upon it, and run a sharp pencil around inside and outside of the mask. Place this sheet in the typewriter with a carbon sheet back of it, the carbon surface against the back of the tracing paper. Write within the inner window line. When taken from the machine, the sheet will have the ink of the ribbon on one side and the carbon of the transfer paper on the back, giving a double density for projection. If the written matter is not centered in the window, the mask may be adjusted over it, the pencil run around the outside of the mask, and the sheet trimmed to the new margin; then bind between cover glasses with gummed paper.

Unless skillful in making the Roman letters, the script form of writing will produce the more acceptable result, since mistakes in spelling and in form of letters are less likely to occur.

Repair of Slides. The cracking of the glass of a lantern slide usually occurs in the cover glass, not in the photographic plate. Slit the binding strip around the edge, throw away the cover glass and substitute another which has been cleaned with alcohol and polished with a chamois or piece of newspaper; rebind with a new strip of gummed paper. If the photographic plate is broken, it is better not to attempt repair upon a rented slide. If you own the slide, it may be repaired as follows: *Place the broken parts glass down upon a cover glass and cement them to it and to each other with Canada balsam thinned with a little turpentine, leaving them until well set. Then cover and bind; if too thick for the slide carrier, project without cover glass.*

TWO SCENES FROM PHOTOPLAY, "HER MASTER"
Courtesy of *Selig Polyscope Co., Inc., Chicago*

SCENE FROM PHOTOPLAY, "THE FAIR DENTIST"
Courtesy of *Independent Moving Pictures Co., New York*

MOTION HEAD

PART I

PORTRAYAL OF MOTION

Abstractly considered, apart from the means for projecting it and from the means for recording it, the motion picture is a picture in which motion is the prime feature. It is a picture so recorded that, itself a record of a moving thing or set of things, it, when properly viewed, will reproduce to the viewing person not only the outlines and details of the objects pictured but also the motion of the objects pictured.

A running horse portrayed by a fixed picture, such as a lantern slide or fixed print, will show the outlines of the horse in full detail in the properly lighted portions of the animal and of the background; it even will suggest motion, by reason of the position in which the animal is portrayed, perhaps with two feet off the ground or even galloping with all four feet clear of the earth; but in such a picture the motion is only suggested by the attitude portrayed by the still picture. The motion picture must do more than merely suggest the motion of the subject photographed; it actually must show the motion so that there is no doubt in the spectator's mind that the object being exhibited is in motion, or was in motion at the time it was photographed. Yet the motion picture in itself is a dead, inert photograph. How, then, is motion portrayed in it?

Go back to the thought of motion in the subject itself. In what way is motion manifested to the spectator viewing the subject? The movement of the subject is known only by observing it twice and noticing whether it is or is not in the same place or position both times. If it is in the same place both times it is observed, then we say that the subject is still. If it is, upon a second look, in a position or location different from that of the first look, the observer says that the subject has moved. Now looking a third and fourth time, and noting that each time the subject is in a different

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position from any of the other positions which it has held, the observer says that the subject is moving continuously, and if the differences are all the same, and if we have looked at regular intervals, the observer concludes that the subject is moving at a uniform rate.

Looking at a thing several times to see whether it is moving is an act performed unconsciously. The eye cannot look at anything for less than one-fiftieth of a second, because of a peculiar property of the eye called "persistence of vision," and when anything is seen in any position, it is seen for that length of time. If it is not looked at longer than that, the impression of motion is not given. Looking at it for half a second, it is seen successively in twenty-five different positions, or the equivalent, and when the observer looks at an object for half a second to see whether it is moving, and finds that it is moving, he really has looked several short looks joined each after another, and in each of the brief looks the object has been in a different position from that of the preceding look; proof of motion thus has been received.

Proof of Motion. Proof of motion is conclusive to the human mind when upon looking continuously at a physical object in nature it is observed to change its position. Proof of motion in the subject of a picture may be offered by the same means of making it apparent to the eye; that is, while the eye is looking continuously at the subject portrayed in the picture the subject is observed to change its position in the picture.

A series of pictures may be made with a single camera, which, by close notice, will prove motion. Assume that an amateur photographer with a hand camera is taking pictures as rapidly as his skilled hands will enable him, the subject being a parade passing down a city street. The camera worker is situated on one side of the street opposite a prominent building, of which the two corners and the central door may be seen in each picture made of the procession. When these pictures are developed and printed, it is noted that in one picture a carriage drawn by distinctive white horses is seen at the right of the picture, apparently entering the picture, judging from the attitude of the horses and the direction of their heads. This suggests motion, but does not prove it. Another picture, however, shows the horses half-way between the corner of the building and the central door; another picture shows the horses opposite the door of the building, with the carriage still close behind; still another picture shows the horses near the left of the picture, with the carriage close behind and the heads of the horses still toward the left. By comparing these pictures, the thoughtful observer will conclude, and correctly, that the horses and the carriage were moving while the series of pictures was being taken. These pictures, when taken together as a series, are pictures of motion and show motion if one studies to see it. The modern perfected motion picture is but the elaboration of this method of recording motion, and the projected motion picture is but a perfected method of viewing it.

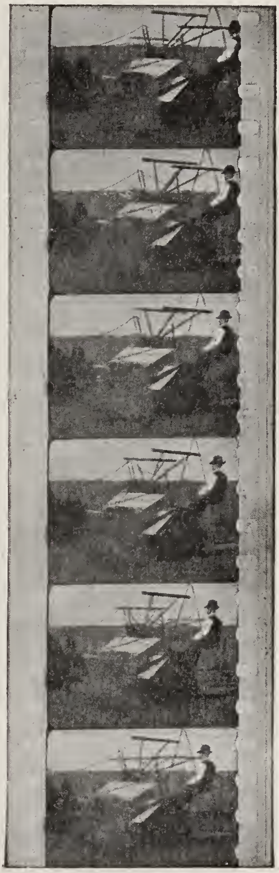


Fig. 1. Motion-Picture of Harvesting Machine in Operation

Perfected Motion Picture. The perfected motion picture makes a series of pictures similar to the series of the procession, but makes them so rapidly one after another, with such a short space of time between pictures, that the change or difference between pictures is very small, the motion being shown by increments from picture to picture. Take for example the motion picture of Fig. 1, which shows a harvesting machine or reaper cutting grain in the field. One part of such a machine is a large revolving flail, comprising a wheel-like formation of six or eight slats revolving over the sickle or cutting bar to prevent the cut stalks of grain from falling forward and to control their fall backward over the sickle bar. This wheel of slats revolves rapidly as the reaper is driven across the field, cutting the grain. Note the picture for the motion of the slats. In the top picture, the slat next the top reaches to the driver's hat and is exactly in line with the brim of the hat. In the picture next to the top figure, taken only one-fourteenth of a second later in time, the slat is not seen at the brim of the driver's hat but noticeably above the brim, and much nearer the top slat, for the top slat is descending. In the third picture, the slat being watched is as high as the top of the driver's hat and is higher than the slat, formerly the top slat and now going down. In the fourth picture of the series the slat being watched is slightly above the height of the driver's hat. In the fifth picture, taken about a quarter of a second after the first picture, the slat being watched has reached nearly its full elevation at the top of the wheel, and the next slat has reached the height of the driver's shoulder. In the sixth and last picture of the series, the slat has moved from the driver's shoulder to the height of his chin. Also note the position of the driver. In the first picture, not all of his body is in the picture; in the second, it is all in the picture; in the third, there is a space between his body and the margin of the picture; in the fourth, the space is wider; and in the fifth and sixth, the space between driver and edge of picture continues to widen.

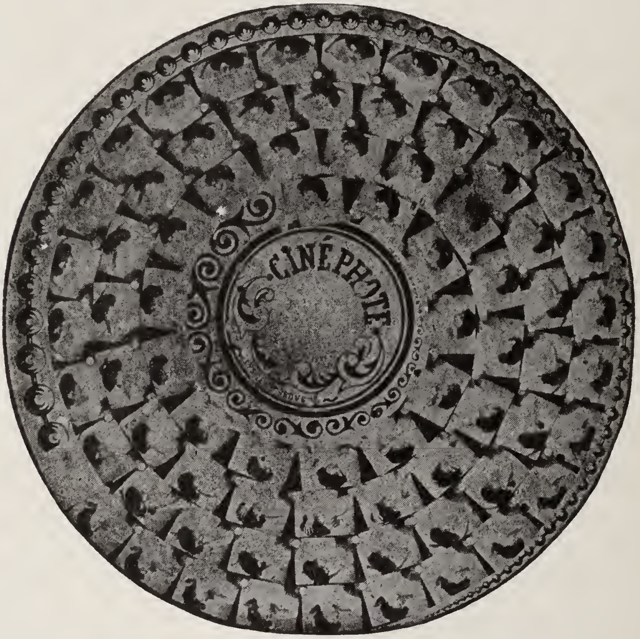


Fig. 2. Motion-Picture Portrait of a Lady

In Fig. 2, a motion picture is shown of circular form instead of strip film form. In this figure, it may be determined by studying the small pictures in sequence that the lady begins and ends the picture with a profile view, but turns her full face toward the camera during the progress of the picture, also she raises her hands to her head as though arranging her hair.

In both Fig. 1 and Fig. 2, the difference between any two consecutive pictures is so small that the pictures are alike except upon the closest inspection.

In taking pictures of objects which are in motion at such speeds as the eye can follow easily, and where the desire is to reproduce the motion pretty much as it was seen by the eye when viewing the physical object, an interval of about one-fourteenth of a second is taken, the object being photographed at the end of each one-fourteenth second, as is the case with the harvesting machine. In the case of motions which are so slow that the eye with ordinary observation cannot notice the motion, a longer interval of time is conveniently taken. A growing plant may be photographed once each day, and not oftener than once each hour unless it is desired to portray the opening of a single blossom; with these pictures taken at these comparatively long intervals, the change between successive pictures will be very small. In the case of motions which are so fast that the eye cannot follow the motion, a much shorter interval of time must be taken, in order that the change in the position of the moving object in successive pictures will be very small. The wings of an insect in flight move so rapidly that to the eye they are but a blur, and to

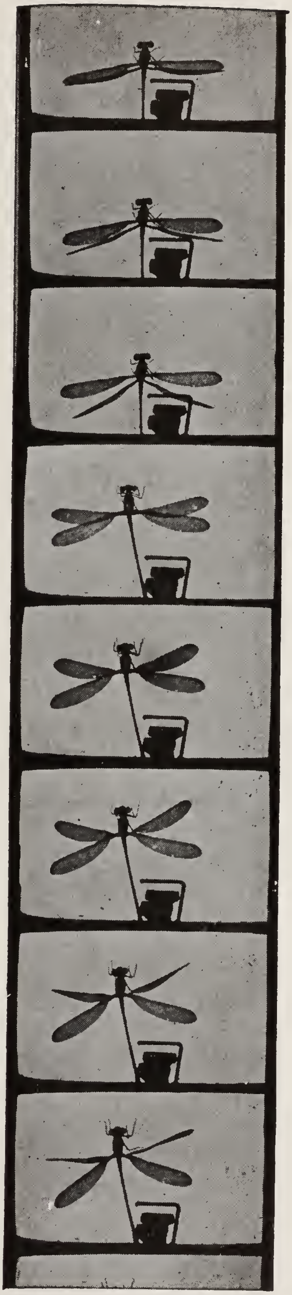


Fig. 3. Motion Picture of an Insect, Made at High Speed

photograph them in a manner that will reveal their proper motions for study requires that they be photographed at much shorter intervals than one-fourteenth of a second. Pictures of this class have been taken at the rate of two thousand pictures in one second. Fig. 3 shows such a picture, the subject being a dragon-fly in full flight. Motion pictures of bullets in flight have been taken at the rate of five thousand pictures in a single second.

This is the motion picture—a picture which shows a record of the successive positions taken by a moving object in successive intervals of time. Whether the picture takes the form of pictures in a row upon a transparent celluloid strip, as the original of Fig. 1, or whether it takes the form of a spiral line on a souvenir postcard, or whether the successive pictures were taken at the rate of fourteen per second, fourteen per year, or fourteen in one-hundredth of a second, all is immaterial, since in any of the cases the fundamental requirement is fulfilled and it is a picture of motion.

Viewing Devices. The perfected projecting machine is but one form of viewing device. Just hold a slip of white paper above the film gate and watch the picture film as it enters the gate; the full motion of the drama takes place there. The intermittent mechanism presents picture after picture at regular and proper speed, and the motion of the picture is seen without projection.

With the card of Fig. 2, the method of viewing is entirely different. The card is placed upon a light carrier, similar to the disk of a talking machine using the flat type of record; an eyepiece is conveniently placed, and as the disk of the picture revolves with a step-by-step movement, the eyepiece moves across as the reproducer needle of the talking machine does. Thus the pictures are seen in order. By taking a transparent print from the negative, projection upon a small scale may be accomplished.

With the picture strip of Fig. 1, it is necessary only to see the pictures successively, and preferably for ordinary scenes to view them in succession at the same speed that they were taken by the camera. To do this, some device is required to take away the first picture and substitute the second picture, then to take away the second picture and substitute the third, and so on indefinitely, that all of the pictures of the series may be viewed by looking at the same viewing position, as by looking at a screen upon which the pictures are projected in rapid succession. Further, to attain the illusion of motion in the picture, the spectator should be deceived, if possible, into believing that he is looking at the same picture all of the time, at least in so far as the fixed objects of the picture are concerned. This illusion can be obtained by making the shift from one picture to another imperceptible to the spectator, which is done by making the time of shift as brief as possible, bringing it at least reasonably near to the limits of persistence of vision.

Persistence of Vision. The human eye does not see an object instantaneously. Time is required for the muscles and nerves to act. What length of time is required by the eye and brain to appreciate a view after the light has fallen upon the lens of the eye has not been recited, nor has it been told what length of time is required for the eye to cease seeing the vision after the light has ceased to fall upon the lens, for the eye is slow about quitting as well as beginning; but it has been established that the eye seems to see any view probably one-fiftieth of a second longer than light actually falls upon the lens of the eye This action of the human eye is called by the name, "persistence of vision," because vision seems to remain or persist in action after the thing viewed actually has vanished.

One effect of the persistence of vision is that, when two views are seen with an interval of not more than one-fiftieth second between the two, the eye blends the two and, therefore, does not appreciate the interval of darkness which has occurred between the two. If the pictures are entirely unlike, there is a blur of confusion of the two. If the pictures are alike in some details and different in other details, then it seems to the eye that the similar details have not changed and that the unlike details have changed.

In the dissolving lantern, with two views showing a different use of figures before the same background or scene setting, skilfully dissolved, it seems to the spectator that the background details have not changed, that the same picture has been viewed continuously, but that the figures of the picture alone have changed their pose.

In the series of photographs of the procession studied as an example, it was by the comparison of a moving object with a fixed object in the picture that motion in the fixed object was proven. In the same manner, it is by comparison of moving and fixed objects in the projected motion picture that motion of the actors is made so realistic and so natural in its execution that it seems a reproduction of true life and the spectator is brought to realize that he is watching a picture of motion rather than a picture of inanimate things, or a picture in which motion is merely suggested as an art or trick or device. To secure this illusion, the fixed objects of the picture must remain absolutely motionless upon the picture screen.

With the perfected motion pictures and motion-projecting machine, exactly the illusion of the dissolving lantern is desired. Two successive pictures must be projected with such skill that the spectator is deceived into believing that he is looking at a single picture of a scenic setting or fixed objects of the picture, and that, watching a single picture, the moving objects have changed their positions.

Many projecting devices embodying the principle of the dissolving lantern—namely, the principle of projecting the second picture before the first picture is taken away and then of projecting the third picture before the second picture is taken away, and so on through the series—have been suggested and some of them have been operated successfully. However, the projecting device which has come into general use depends upon the phenomenon of the persistence of vision to smooth over the change from picture to picture, the change being made so quickly and so smoothly that the human eye cannot detect the coming of the new picture or the going of the old, nor guess at the interval of darkness or of blur which occurs between the two.

Projection by Persistence of Vision. The method of projection which takes advantage of the persistence of vision fills the requirements of the case entirely and is entirely satisfactory when well done. Its theory is that the first picture may be shown upon the screen, that the first picture may be cut off from the screen by a shutter, that the film may be shifted to bring the second picture in position for projection, and that the shutter may be removed to permit the projection of the second picture, all in a space of darkness upon the screen so brief that the first picture projected will persist in the vision of the spectator until the change in the motion head has been made and the second picture is upon the screen, when the spectator will see the fixed objects of the view in their places in the second picture as in the first, with the moving objects of the view changed to their next position, whereby the spectator believes that he has had continuous vision and believes that the fixed objects have been upon the screen in fixed position all the time, and that the moving objects also have been upon the screen all of the time but that they have moved upon the screen to the new position. In the same manner, the second picture persists in the vision of the spectators until the dark interval is over and the shift has been made and the third picture is projected; the third picture persists until the fourth picture is projected, and so indefinitely until the picture is out, retaining all fixed objects in continuous and stationary vision before the spectator by the phenomenon of persistence of vision and showing the motion of all moving objects in the successive pictures, the pictures showing so small an amount of movement between successive pictures that the motion seems smooth and continuous and not jerky step-by-step projection which it really is. That jerkiness, by the art of the film maker and assisted by the art of the projection operator, must be smoothed out.

Motion Mechanism. The slowest speed at which it has been found practicable to project a series of images having ordinary motion, as of actors walking, and to smooth out the jerkiness which would be expected by the step-by-step nature of the projection when the persistence-of-vision method is used, is about fourteen pictures per second. Fourteen pictures are to be projected each second, and with uniformity. To expect the operator to make fourteen shifts, or fourteen voluntary motions resulting in shifts, each second, as in changing lantern slides, and to do it with regularity, is quite an impossible requirement, so a machine has been devised for doing the shifting in an automatic manner, at regular intervals, the length of the intervals depending only upon the speed at which the machine is driven.

When driven by an electric motor—a great convenience in some ways but a very great disadvantage in other ways—the entire operation is quite automatic, it being necessary only for the operator to adjust and start the machine and the projection of motion for some twenty minutes follows, presumably in an entirely satisfactory manner if the preliminary adjustments have been perfect. When not driven by a motor, the operator is provided with a crank, which is turned at a constant speed, and which results in the automatic shifting being performed under the driving power of the crank handle.

The automatic shifting device is called a *motion head,* and it replaces in functions only the slide holder of the lantern, all the other portions of the fixed optical lantern being retained. All the features of the optical lantern for song slides are retained in use with the motion head except the projecting or objective lens, a special lens for the motion pictures being carried upon the motion head itself.

OPTICAL SYSTEM FOR MOTION PICTURES

The optical system of the motion-picture lantern adds to the system of the stereopticon, two shutters, an intermittent shutter and a fire shutter. Because of the short-focus lens required for the greater magnification of the motion-picture image as compared with the fixed lantern slide, the motion-picture image or film strip of images is placed farther away from the condensers than is the fixed slide. With these two modifications, the two optical systems cease their differences, and the fundamental principles of one are the fundamental principles of the other. The arrangement of elements for the motion-picture system is shown in its usual form in Fig. 4, the picture screen or viewing screen, which would be located properly far to the right, being omitted from the picture in order that all the other elements might be drawn to a larger scale, more clearly and distinctly.

Lamp. As has been described under the discussion of the optical lantern for fixed slides, the motion-picture arc lamp is of maximum strength, giving a very strong light and a very intense heat, such as is suitable for the motion picture alone, and unsuitable for the lantern slide.

Condensers. The condensers are the same as used for the optical lantern for fixed slides, and are the same condensers, being carried by the lamp house from the motion head to the stereo lens, and again from the stereo lens to the motion head, but where the requirements for condensers for the motion head differ in any way from the requirements for the fixed lantern slides, the motion head should be given preference. Proper instructions for the adjustment of the condensers for the motion head are repeated here, as though they were to be used for the motion-head work alone.

Back Condenser. This is the condenser at the left in the diagram, next to lamp *L.* It is shown in the diagram as the thicker of the two condenser glasses, and usually is so in practice. The focal length may be as short as 4½ inches. Its length of focus governs the distance of the lamp *L* from the back surface of the glass, and its length of focus in turn is controlled to some extent by the size of the lamp house, since the back condenser must take the rays of the lamp from a lamp position within the limiting range of movement permitted by the lamp house. Most lamp houses will permit the use of back condensers 4 to 8 inches focal length.

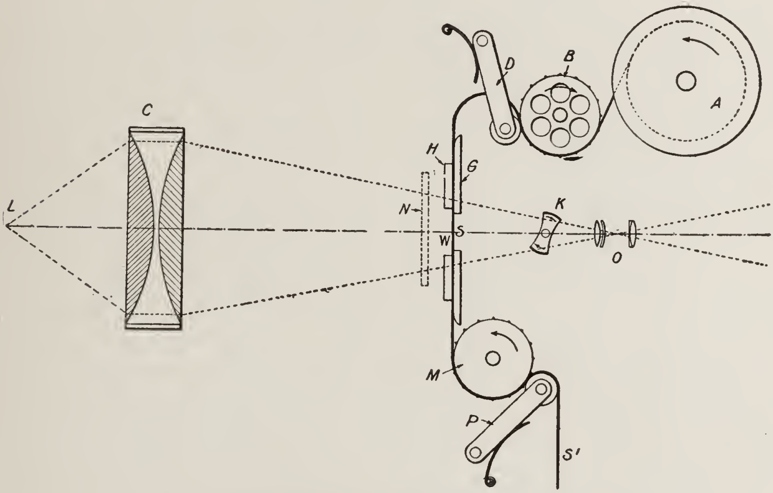


Fig. 4. Optical System for Motion-Picture Projection

A—Feed Reel; *B*—Upper Steady Sprocket, or Top Feed; *C*—Condenser Case and Condenser Glasses; *D*—Presser Roller and Arm for Top Feed; *G*—Film Gate; *H*—Tension Plate for Film Gate; *K*—Intermittent Shutter, Barrel Type; *L*—Lamp, or Point of Location of Arc; *M*—Intermittent Sprocket; *N*—Fire Shutter or Safety Shutter; *O*—Objective Lens or Projection Lens; *P*—Presser Roller and Arm for Intermittent Sprocket; *S*—Film in Film Window or Aperture of Film Gate; *S'*—Film leaving Intermittent Sprocket to Basket. The dotted lines represent the outer rays of the beam of light, and pass to the right to the Picture Screen, which is not shown in the figure.

The shorter the length of focus of the back condenser, the thicker will be the glass in the middle and the closer must be the lamp *L*, consequently the greater the heat upon the surface of the glass; incidentally, also, the brighter the light upon the picture screen. On the contrary, with a condenser of longer focus, the glass will be thinner in the middle, and will be farther away from the lamp, thus lessening the danger of breaking the glass. Incidentally, also, the less light will fall upon the condenser and, therefore, the less light will there be upon the picture screen.

The length of focus of the back condenser may be considered a compromise between the strength of the light on the screen and the risk of condenser breakage. Any length of focus within wide limits—4 to 8 inches, or in a large lamp house even much more than this—will give a properly distributed lighting of the screen, varying in brightness according to the length of focus used.

The shorter length of focus for the back condenser will require greater skill on the part of the operator in keeping the light in focus. The light being nearer, a slight change, say, an eighth of an inch, in the position of the arc, will make more difference upon the picture screen than the same amount of change would make with a condenser of longer focus. The longer focus of condenser (thinner glass) makes the lamp much easier to adjust for a smooth, evenly-lighted picture screen (provided *always* that your front condenser is of proper focal length) unless the back condenser happens to be so long in focal length that the lamp cannot be brought far enough back in the lamp house for it; such a condenser is too long for the lamp house, and good projection cannot be had with it. Of course, some sort of quality of picture can be thrown upon the screen with it, but it makes poor projection.

Front Condenser. This is the condenser at the right in the diagram, the outside one of the lamp house. It is shown in the diagram as the thinner of the two condenser glasses. The focal length should be exactly right to cause the rays of the lamp to come to a focus at the focal center of the objective lens *O*, whose position is determined by adjusting it properly in focal length and position in the motion-head lens mount in order to focus the picture film *S* properly and in proper size upon the distant picture screen.

Condensers are offered by all supply houses in lengths which vary by 1 inch, usually being offered in 4½, 5½, 6½, and 7½ inches. They may be obtained from the makers in focal lengths of 4, 4½, 5, 5½, 6, 6½, 7, 7½, 8, 8½, 9, 9½, 10, 10½, 11, and 12 inches. In addition, they may be made to order of any length called for.

With a 9 by 12 foot picture at a 50-foot throw, an objective lens at *O* having a focal length of about 4 inches would be required. In connection with this there would be required for the lantern slides a stereo lens having a focal length of about 12 inches. With a difference of 8 inches between the two lenses, the distance from the lantern slide in its carrier to the motion-picture film in its gate should be about 8 inches, equal to the difference between the lens lengths

Taking the motion head as it stands on the table, the length of the front condenser is calculated in either case by simple addition. The focal length of the motion-picture lens is added to the distance from the film in its gate to the middle of the condenser box. In the instance taken, of a 4-inch lens, with 8 inches from the film to the slide position and another 2 inches back to the middle of the condenser box, it gives a total length of 14 inches for the focal length of the front condenser. This is the limit. A condenser longer than 14 inches will not give as good projection as one shorter; the front condenser should be 14 inches focal length or shorter.

Condensers as a Pair. The condenser glasses should not be of too great difference in focal length, as the lamp adjustments again become difficult, and are easier with the condensers more nearly of equal lengths. For the maximum illumination in the instance considered, a 50-foot throw and a 4-inch lens, with 14 inches from center of condensers to center of lens, the theoretical focal lengths required would be a 5-inch glass for the back and a 14-inch glass for the front. This combination gives an equivalent focal length of about 4⅛ inches for the pair of glasses. About the same equivalent length for the pair of glasses would be obtained by the combination of a 5½-inch glass and a 10½-inch glass, by the combination of a 6-inch glass and a 9-inch glass; by the combination of a 6½-inch glass and an 8-inch glass; or by the combination of two 7-inch glasses. Of these combinations, the 5 and 14 combination would be the hardest to work in practice but would be productive of the best results when properly worked by the skilled operator. The 7 and 7 combination will not give good results with any amount of skill on the part of the operator. The best combinations to use are the 6 and 9 or the 5½ and 10½; the latter is better if the glasses can be obtained, and its use lies well within any careful operator's skill.

Another consideration is the limits of the cone of light as determined in dimensions by the position of the optical center of the motion-picture objective lens and the sides of the film-gate window. This must not be larger at the condenser than the face of the condenser glass. In the instance assumed, the diagonal of the ¾ by 1-inch film-gate window is just 1¼ inches, and its distance from the optical center of the lens is about 4 inches (4.007″), while the distance from the optical center of the lens to the condenser face is about 13 inches.

By the proportion, $4 : 1\frac{1}{4} :: 13 : A$, where A is the diagonal of the cone upon the condenser face, a value of 4 inches for the dimension A is obtained, which is easily cared for by the usual condenser of $4\frac{1}{2}$ inches diameter of face when the condensers are of proper focal length and the lamp is properly adjusted.

When the cone, formed by the limits of the optical center of the lens and the corners of the film aperture, falls outside of the front condenser surface, the corners of the pictures on the screen will be dark. The remedy is to move the motion head as a whole nearer to the condensers, even though this change should bring the focal center of the motion-picture lens nearer to the condensers than the focal center of the lantern slide lens, and thereby require a change from the motion head to the stereo lens, or back.

For the best lighting of the screen, the front condenser should be as long as possible, but should be a little shorter than the limit, since the exact limit is hard for the operator to work satisfactorily, and a condenser a little too long is much worse for the picture than one a little too short.

Short Rules for Condenser Lengths. *The front condenser glass shall have a focal length two inches less than the distance from the middle of the condenser box to the middle of the motion-picture objective lens. The back condenser should be five and one-half inches in focal length.*

The back condenser may be four and one-half inches to force the light upon the picture screen at the risk of breaking more condensers.

The back condenser may be six and one-half inches to reduce the breakage of condensers at the cost of a slight reduction of the brightness of the picture screen.

When the front condenser is too short, the correction cannot be accomplished by substituting the back glass with one a little longer.

Use the longest focal length (the thinnest glass) for the front glass of the condensers.

Lenses. The motion-picture lens is similar to the stereopticon or fixed picture lens in all respects except in that of focal length. It is similar in focal length, too, so far as the fundamental principles of projection are concerned, and its focal length, size of picture produced, and required length of throw may be determined by the rules, both for approximation and exactness, which have been given in connection with the discussion of lenses for stereopticon work.

TABLE I

Showing Size of Screen Image When Moving Picture Films Are Projected

Size of Mask Opening $\frac{11}{16}$ by $\frac{15}{16}$ inch

Equiv. Focus Inches	15 ft.	20 ft.	25 ft.	30 ft.	35 ft.	40 ft.	45 ft.	50 ft.	60 ft.	70 ft.	80 ft.	90 ft.	100 ft.
2⅛	4.8	6.4	8.0	9.6	11.3	12.9	14.5	16.1					
	6.5	8.7	11.0	13.2	15.4	17.6	19.8	22.0					
2½		5.4	6.8	8.2	9.6	10.9	12.3	13.7	16.4				
		7.4	9.3	11.2	13.1	14.9	16.8	18.7	22.4				
3		4.5	5.7	6.8	8.0	9.1	10.3	11.4	13.7	16.0			
		6.2	7.7	9.3	10.9	12.4	14.0	15.6	18.7	21.8			
3½			4.9	5.8	6.8	7.8	8.8	9.8	11.7	13.7	15.7		
			6.6	8.0	9.3	10.6	12.0	13.3	16.0	18.7	21.4		
4			4.2	5.1	6.0	6.8	7.7	8.5	10.3	12.0	13.7	15.4	
			5.8	7.0	8.1	9.3	10.5	11.6	14.0	16.3	18.7	21.0	
4½				4.5	5.3	6.2	6.8	7.7	9.1	10.6	12.2	13.7	15.4
				6.2	7.2	8.4	9.3	10.5	12.4	14.5	16.6	18.7	21.0
5					4.8	5.4	6.1	6.8	8.2	9.6	10.9	12.3	13.7
					6.5	7.4	8.4	9.3	11.2	13.0	14.9	16.8	18.7
5½					4.3	4.9	5.6	6.2	7.4	8.7	9.9	11.2	12.4
					5.9	6.7	7.6	8.4	10.2	11.9	13.6	15.3	17.0
6						4.5	5.1	5.7	6.8	8.0	9.1	10.3	11.4
						6.2	7.0	7.7	9.3	10.9	12.4	14.0	15.6
6½							4.7	5.2	6.3	7.3	8.4	9.6	10.6
							6.4	7.1	8.6	10.0	11.4	13.0	14.5
7							4.4	4.9	5.8	6.8	7.8	8.8	9.8
							6.0	6.6	8.0	9.3	10.6	12.0	13.3
7½								4.5	5.4	6.4	7.3	8.2	9.1
								6.2	7.4	8.7	10.0	11.2	12.3
8									5.1	6.0	6.8	7.7	8.5
									7.0	8.1	9.3	10.5	11.6

The difference between the size of the lantern-slide window or the mask window of the slide, and the motion-picture window, must be borne in mind. The size of lantern slide usually calculated for in computing lens dimensions is 2¾ inches by 3 inches, a dimension which is exceeded in many slides. In the matter of the motion picture as commercially used in the theater, the size of the window for projection is called ¾ inch by 1 inch, is never more than that, and is never less than $\frac{11}{16}$ by $\frac{15}{16}$ inch.

The projected picture of the motion-picture film always is about three-quarters as high as it is wide, and this proportion must be taken into consideration when calculating upon the dimensions of the picture which is to be thrown upon the picture screen.

The desirable results of operating lantern slides with a slide-carrier window mask have been discussed in connection with the operation of the optical lantern for fixed slides. The same good results are obtained in motion pictures by the use of a window mask in the window of the film gate, the aperture plate, as it is called, having an aperture just a little smaller than the pictures upon the film, so that the side lines of the picture upon the screen are formed not by the film picture but by the aperture plate of the motion head. Most projecting machines are equipped with an aperture plate which "trims" the picture $\frac{1}{32}$ inch all around, reducing the size of the visible picture to $\frac{11}{16}$ by $\frac{15}{16}$ inch.

Table I gives the size of projected picture with different lengths of throw and with different focal lengths of projecting lenses with an aperture or mask opening $\frac{11}{16}$ by $\frac{15}{16}$ inch.

At the left in the first column is given the lengths of the lenses, from $2\frac{1}{8}$ inches to 8 inches, for which the table is computed. The columns at the right of the first column are arranged for the different lengths of throw, the length of throw considered in each column being mentioned at the top of that column.

For each length of lens, there are two figures in the columns for length of throw. These two figures are the height and width upon the screen of the projected picture which will be secured by using the length of lens mentioned at the left of the pair of figures and using it with the throw mentioned at the top, above the pair of figures.

From Table I may be obtained:

The lens length required to give a desired picture when the throw is known.

The size of picture which will be given by any certain lens when the throw is known.

The length of throw to be taken to secure a picture of a desired size with any certain lens.

To Take Lens Length. Find in the table the length of throw which you have. This will be found as the number of feet mentioned at the top of one of the columns. Now look down in this column until a pair of figures is found giving the size of picture which you desire to project. When this pair of figures is found, lay a card

SCENE FROM PHOTOPLAY, "THE HERDERS"
Courtesy of *Selig Polyscope Co., Inc., Chicago*

across the book page, even with the lines and just showing above its edge the pair of figures showing the desired size of picture in the proper length of throw column. At the left of the lens table and just above the edge of the card will be the length of focus in inches of the lens required for that size of picture.

Example. You have a 70-foot throw, and desire a picture about 12 feet wide. Finding the column marked at the top 70 feet and looking down that column, the pair of figures, 8.7 by 11.9 is found, and placing a card on the page the figure 5½ is seen at the left above the edge of the card. An objective lens of 5½ inches equivalent focal length will give a picture about 8 feet 9 inches high by about 11 feet 10½ inches wide.

To Take the Picture Size. In this problem, you have the lens which you are thinking of using, or must use, and you have the length of throw over which it must be used. At the left of the page, find the focal length of the lens in inches, either as marked on the lens, or as measured as described for stereo lenses for the optical lantern. Place a card across the page just below the figure of the length of lens, so that the card will show above its edge a row of pairs of figures of which in each pair the lower figure of the pair will be the larger figure. Now find the length of throw at the top of the narrow columns, and under that length and at the edge of the card will be found the pair of figures which tell the height and width of the projected picture when that lens is used over that throw.

Example. You have a 4-inch lens and a 40-foot throw and desire to know what size of picture will be projected. At the left of the page find the figure 4 and place a card across the page so that it will show the row of figures beginning with 5.8 and ending with 21.0, thus showing a double row of pairs of which the lower figure of each pair is the larger of the pair. Now find 40 feet at the top of one of the narrow columns and below it is found the pair of figures, 6.8–9.3, meaning that with that lens and that throw the picture will be 6 feet 9½ inches in height and 9 feet 3½ inches in width.

To Take the Length of Throw. Knowing the lens which must be used and the size of picture desired, look at the left of the table for the lens length, place a card across the page and look along the card for the size of picture, then go up the column to the top and there will be found the length of throw which will give that size picture with that lens.

Example. In a parlor, a screen 6 feet square has been provided; you have only a 4-inch lens. At the left of the page, find the figure 4 and lay a card across the page; the first pair of figures along the edge of the card is

4.2–5.8, which will go on the screen, but the next pair, 5.1–7.0, will give a picture too large for the screen. It is seen, therefore, that the operator must not place his projecting machine farther away than 25 feet (the figure at top of column above the pair, 4.2–5.8) or the projected picture will be too large for the screen.

Accurate Calculations. When sizes are needed very accurately, they should be calculated according to the rules given for calculating data for lenses for lantern slides for the optical lantern, using the three equations:

$$ST = PD \qquad (1)$$

$$F^2 = (D - F)(T - F) \qquad (2)$$

$$D + T = H \qquad (2)$$

In these equations, when used in the calculation of data for motion picture projection,

S equals the width of the film aperture or mask opening when calculating for the width of the projected picture—make S equal to 1 inch or $\frac{15}{16}$ inch according to the dimension of the aperture—and equals the height of the film aperture when calculating for the height of the projected picture—make S equal to $\frac{3}{4}$ inch or $\frac{11}{16}$ inch, according to the dimension of the aperture.

T equals the length of throw, lens to screen, which may be measured closely when the length of the lens is known approximately, and when T may be measured the equation for S may be written in a simpler form if desired.

P equals the picture dimension as projected on the screen, being the height when S is the height and being the width when S is the width of the film aperture.

D equals the distance from the focal center of the lens to the picture film in the film window; it is not required to be known in the course of calculations, but is included in the equations because it influences the size of the projected picture, sometimes as much as 1 inch in the width of a picture 12 feet wide.

F equals the focal length in inches of the motion-picture objective or projecting lens.

H equals the distance, screen to film.

Approximate Calculations. Use the formulas or equations given for lantern slides. These calculations are useful when the exact length of throw is not given in the table.

The *throw* equals the desired picture width multiplied by the focal length of the lens and divided by the film aperture width, all dimensions taken in inches. That is

$$T = P \times F \div S$$

The *lens length* equals the film aperture width multiplied by the length of throw and divided by the desired picture width, all dimensions taken in inches. That is

$$F = S \times T \div P$$

The *picture width* equals the film aperture width multiplied by the length of throw and divided by the focal length of the lens, all dimensions taken in inches. That is

$$P = S \times T \div F$$

The *picture height* equals the film aperture height multiplied by the length of throw and divided by the focal length of the lens, all dimensions taken in inches. That is

$$P = S \times T \div F$$

Calculations Compared. Assume a 4-inch lens and a 48-foot throw. The accurate calculation gives a picture size of 11 feet 11 inches, while the simpler approximate calculation gives a picture size of 12 feet, approximating the true picture size within 1 inch.

Matched Lenses—Stereo and Motion Head. By the term *matched lenses* is meant a pair of lenses selected to work together, the one as a motion-head lens and the other as a stereo lens, and to give two pictures upon the screen which shall have the desired relation in size.

Lenses may be matched for height, for width, or for area. If the screen is square, the stereo lens may be matched to project a picture as wide as the motion picture lens. If the screen is the shape of the motion picture, then the stereo lens may not project a picture higher than the motion-picture projection. If the screen is between the two, or if it is ample in size and the operator prefers a picture of equal area, the lenses may be so matched. The argument in favor of equal area is that the shift from lantern slide to motion film is less objectionable to the operator, but when the possible difference in densities is considered this objection seems to have little force.

To match lenses for the same width of picture on the screen, the stereo lens will be just three times the focal length of the motion picture lens, figuring 1 inch as the width of the window in the film gate and 3 inches as the width of the mask opening of the lantern slide. With the $\frac{15}{16}$-inch film window, the stereo lens should have three and one-fifth times the focal length of the motion-head lens.

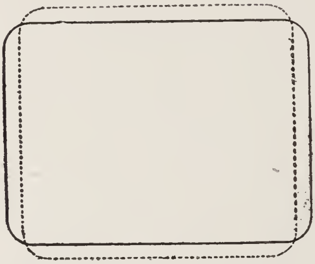


Fig. 5. Diagram of Edges of Pictures on Screen with Lenses Matched to Give Equal Area

For equal height of picture on the screen, ¾-inch high film window, and 2¾-inch high lantern slide mask opening, the stereo lens should be three and two-thirds the focal length of the motion-head lens; and with a film window $\frac{11}{16}$ inch, the stereo lens should be four times the focal length of the motion lens.

For equal areas, the stereo lens should be three and one-third times the focal length of the motion-head lens for a film window ¾ inch by 1 inch or full size of the motion film. The stereo lens should be about three and three-fifths the focal length of the motion-head lens for a film window $\frac{11}{16}$ inch by $\frac{15}{16}$ inch. The arrangement or relation of the two pictures upon the picture screen when projected matched for area is shown in Fig. 5.

Adjustable Lenses. These lenses are made to change the equivalent focal length of the lens by turning the front rim of the lens, Fig. 6. The knob moves the whole lens. Such a lens, at a 40-foot throw, will project a picture varying, say, from 8 feet in width to 14 feet in width; that is to say, its focal length can be adjusted from 2½ inches to nearly 5 inches by turning the front rim. After turning the front rim to change the picture size, the lens must be readjusted with the knurled knob to focus properly on the screen. The price is as much as two or three ordinary lenses of the same quality. Any lens will project its picture slightly smaller by unscrewing front and back lens cells a few turns of the screws. This is not to be recommended for indiscriminate practice.

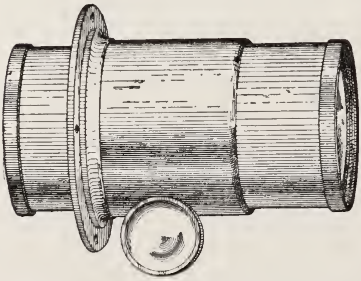


Fig. 6. A Lens Having Adjustable Focal Length, for Motion Head

THE SHUTTER

In projection by persistence of vision, the secret of successful work is to make the change of picture on the screen without permitting the spectator to see or to appreciate the change in any way other than by the shift of the moving objects in the image portrayed. Theoretically, it is possible to shift the picture by a jerk so quick that the transfer from the old to the new picture is made without leaving upon the eye of the spectator an impression of motion of the fixed objects because the motion was so brief.

That this is possible is proven by the successful operation of many shutterless toy projectors, projecting film of standard dimensions by means of an oil lamp upon a small screen, such as 3×4 feet. The picture is steady and flickerless. The result is dependent upon the weak illumination of the oil lamp. When a miniature incandescent lamp is placed in such a toy machine and caused to glow brightly by a sufficient battery, thereby increasing the intensity of illumination upon the screen, the shifting becomes apparent at once, manifesting itself by "rain" or "light rain," sometimes called "halo." This is a streaking of the picture vertically, caused by the rapid passing of the light spots of the pictures while moving.

To avoid "light rain," the motion head is provided with a shutter for cutting off the light from the picture screen while the film is in motion during the shift. This obscures the "light rain" and gives again a satisfactory projection, until the intensity of illumination is increased further, when the picture change begins to become apparent again, this time by a flickering of the illumination of the screen every time the shutter cuts off the light for the change.

To make the flicker less noticeable, effort is made to reduce the time of the dark interval until it falls within the limits of persistence of vision. With the widely used "Geneva" movement for the intermittent mechanism, it is feasible to have the film stand still four-fifths of the total picture time of one-fourteenth of a second, making the change of pictures in the remainder of one-fifth of one-fourteenth of a second, or in one-seventieth of a second; but the shutter begins to cut off the light before the film begins to move and then does not restore the full light until after the film has come to rest, thus lengthening the interval of reduced light. Furthermore, the more intense the screen illumination, the more noticeable is the flicker for the same shutter setting and the same machine speed, indicating that the brilliancy of the picture screen has some effect upon the time during which the vision will persist.

In the same audience, one person will see flickering pictures where another will not, because of the difference in the eyes. Successive scenes in the same reel of film will show flicker or not to the same spectator because of the difference in the opacity of the film image. A scene with a bright white sky will flicker unendurably to nearly all eyes while the interior view following it will run smoothly because of the smaller amount of light on the screen.

The multiple shutter is an invention for reducing flicker. It is used on many prominent machines. The form may be disk, barrel, or cone. The principle is that of shutting off the light twice, or three times for each picture projected, so that the rapidity of flicker is increased until the flicker becomes so fast that the eye cannot appreciate the separate flickerings and blends them all together into a continuous steady illumination by reason of the persistence of vision. In the operation of this shutter, the light is cut off from the screen forty-two times per second and the picture is changed to the next step of the film only fourteen times per second, or every third time the light is cut off.

With a shutter having but one blade, cutting the light from the screen only when the picture is being changed, four-fifths of the light of the lantern is projected to the screen. With the multiple shutter which shuts off one-sixth, then leaves the light on one-sixth, then shuts off one-sixth, and so on, the light given to the screen is three-sixths on and three-sixths off for every picture, giving but one-half of the lantern's light to the screen. Thus the multiple shutter reduces the maximum illumination and thereby reduces the flicker, even as flicker would be reduced if the operator would reduce the current through his arc and give a less bright projection in that way. The multiple shutter much improves the projection in the detail of flicker.

Adjust the shutter accurately, whether single or multiple wing and keep the machine running fast enough to keep the flicker subdued. In scenes which have a particularly bright screen illumination, the light may be reduced by a *tinter*, which is a sheet of colored glass or a plain colored lantern slide or the equivalent, which may be held either between the lens and the screen or between the condensers and the film window

Types of Shutters. There are two principal types of shutters, the barrel shutter and the disk shutter, the latter amplified to the double-disk shutter to secure the advantages of the barrel type.

Barrel Shutter. The barrel shutter is shown in Fig. 7. This shutter is like a barrel with two windows cut in it. When it is arranged to shut off the light as a single shutter, cutting the screen dark once for each picture shift, then it revolves at one-half the speed of the intermittent mechanism, or one revolution of the shutter for two pictures. The light is admitted to the screen when the two windows of the barrel are opposite each other horizontally. The advantage which this shutter has over the disk is the speed with which it cuts the light from the screen and restores it after the shift. The blade near the lens begins to cut the upper rays and the blade near the film window begins to cut the lower rays, and when the shutter is half over the beam of light, the light has been shut off, because the shutter has worked upon both halves at the same time. In like manner, when the shutter begins to admit the light to the screen again, it begins at the middle and as the blades separate the light spreads upon the lens rapidly toward the upper and lower edges, restoring the full illumination very quickly. This shutter usually is placed between the lens and the film window, as shown in the diagram. For the multiple-shutter effect, the barrel shutter revolves once for each picture, cutting the light off twice. The blades then are wider, the windows smaller.

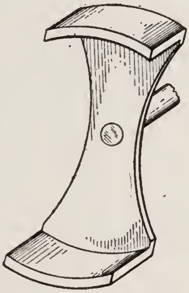


Fig. 7. The Barrel Type of Shutter

Disk Shutter. The disk shutter is a plain disk with a window in it, or a hub with a single wing attached, revolving edgewise as shown in Fig. 8. It is placed in any one of three places—between the lens and the film window; between the condensers and the film window; or before the lens. It is desirable that the light be cut off as quick as possible when the shutter begins to cut it off, and that it be restored just as quickly when the shutter begins to restore it. This advantage was enjoyed by the barrel shutter over the disk shutter so long as the disk shutter remained of small radius; the small radius was enforced when the shutter was placed between the lens and the film window because it must be contained then within the body of the projecting machine; when placed between the film window and the condensers, its size was restricted also, because on the one hand it conflicted with the crank, and on the other hand with the stereolens beam of light.

Before the Lens Shutter. The before-the-lens shutter solved the problem of the quick cut off for the light with the simple disk shutter.

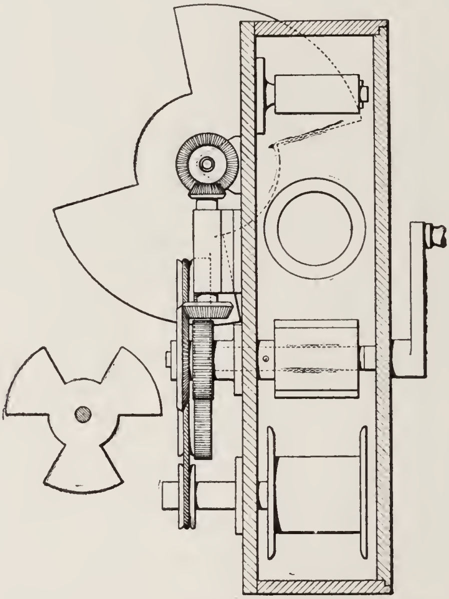


Fig. 8. The Disk Type of Shutter, with Two and Three Wings

The shutter was placed before the lens and was made of large radius. The speed of the shutter near the edge of a 15-inch disk is seven times that of the shutter within the motion head which had an axis only 2 inches from the optical axis of the beam of light, and when the edge of the wing comes to the beam of light streaming from the lens, the beam is cut very quickly. True, the beam of light at this point is larger than it is between the lens and the film window, but the speed of the cutting shutter wing is still greater in proportion.

With the disk shutter for the multiple shutter effect, it may carry three wings, each one-sixth of the circumference of the shutter, or the shutter of two wings may be driven at one and one-half times the rate of the picture shift to reduce the flicker, Fig. 8.

Any shutter may give the multiple shutter effect to reduce the flicker by doubling the speed, where the mechanical details of the motion head permit it.

Multiple-Disk Shutter. This is a shutter consisting of two disks revolving in opposite directions, so that they begin at the same time to cut off the light from both edges of the beam, just as the barrel shutter does. This makes the cut-off still more quickly than the single-disk shutter and serves still further to reduce the flicker. In multiple-disk shutters the disks are not always mounted upon the same shaft or upon the same axis, one disk sometimes working from one side of the beam of light and the other disk from the other side.

Cone Shutter. With its driving shaft set at an angle of 45° to the beam of light, the cone shutter revolves its two wings—one in the beam of light and the other at the side—parallel with the beam. The cone shutter is a shape adapted to save space in the motion head, and give the advantages of the disk without taking the room.

Setting the Shutter. Here is a short rule which applies to every type of shutter and to every type of intermittent mechanism:

Place a piece of film in the motion head, threaded through the film gate and intermittent feed of whatever nature, and frame the picture true in the film aperture, splitting the margin of trim if you are running a 11/16 aperture on a 3/4″ picture. Then advance the intermittent mechanism until the film is being shifted and is exactly in the middle of the shift. At this point, the line of division of the film between the two pictures will be exactly across the middle of the film window. Now set the shutter so that it is dead center over the lens, or dead center on the optical axis.

If you have a multiple shutter and one of the leaves of the shutter is broader than the others, or if one is opaque and the others translucent, then the broad leaf or the opaque leaf is the one to set over the lens when the film is half shifted.

Another rule, which applies only to the Geneva shift and the disk shutter, is:

When the pin is half in the slot, the shutter should be half over the lens.

Fire Shutter. The fire shutter, or safety shutter, shown at *N* in Fig. 4, is a requirement of most city ordinances. It is a shutter for cutting the rays of the arc lamp from the film window when the motion head is not running. It is called *automatic* when it is so arranged that it will fall into place and cut off the light when the film stops, without requiring the attention of the operator to close it. Sometimes its mechanism is such that when the handle is turned it is lifted from the film window automatically, and sometimes it is such that a definite speed must be attained before it will be lifted from the film window.

This fire shutter is a detail which varies greatly with different makes of motion heads. Its general purpose is the same in all—to protect the film from the intense heat of the arc in case the film should stop in the film window, for the arc would cause the film to burst into flame in a few seconds.

FILM GATE

The mechanism of the film gate is so simple that unless its *functions* or the duties dependent upon it are understood the projection operator is liable to neglect it. It is one of the very important parts to be kept in exact condition of adjustment and to be corrected when the slightest wear shows, for one of its duties is the *keeping* of the focus constant upon the screen. It is of little use to adjust the objective lens to focus the film upon the screen in one minute when the film gate will change the position of the film and throw it out of focus the next.

Functions. The functions of the film gate are: *First,* to guide the film so as to prevent any sidewise motion as it passes in front of the film window in the aperture plate.

Second, to flatten the film at the film window and hold it flat so that all of the surface of the film picture may be thrown into focus upon the picture screen by a flat-field lens, and to hold it in the same plane all the time so that the focus when once established by the adjustment of the objective lens will be maintained to the end of the reel and through successive reels.

Third, to prevent vertical jiggling of the images of the series in their comparative locations in the film window, by putting upon the film a tension or restraint to keep it from following by its momentum after the intermittent mechanism has stopped pulling.

Construction. The main plate has two side guides or rails and a film aperture or film window. The two side rails are separated sufficiently to permit the film to pass between but not to take any diagonal position. When threading up the machine, the film is placed in the groove formed by the face of the film gate and the two shoulders or rails forming the side guides for the film; and the tension plate or tension springs are brought to bear upon the edges of the film.

In Fig. 4, the body of the film gate is represented at *G* and the tension plate at *H*. The springs are not shown.

Adjustment of Tension Springs. Where the tension springs do not make direct pressure upon the edges of the film, the tension plate is pressed by tension springs which are adjustable. If the tension of these springs is too tight, they will drag the film at such strain that a weak place or splice will separate under the pull of the intermittent feed; if the tension of the springs is too loose, the picture will "follow" and the projected image upon the screen will jiggle vertically. As the tight spring does not manifest itself unless it be by tearing the film or causing the handle to turn hard, it is less easily detected upon inspection than the loose spring, which permits the picture to jiggle. The adjustment of the tension springs may be attained, therefore, first by setting all of them to the same tension, then by loosening them equally until the picture begins to show upon the screen that the tension springs are too loose; then by tightening them until the picture is steady again. Thus they will be tight enough, without excess pressure.

Care. The film gate and the tension plate both wear where the film rubs between them; where the springs press directly upon the film, the springs themselves wear. Any wear which can be detected will probably be enough to throw the picture out of focus upon the screen from time to time, particularly a film which is slightly warped.

The only remedy for a worn film gate, which permits the focus of the picture to vary from time to time as the reel is turned through, and the lens remains stationary, is to buy new parts—gate body (with some makes of machines it is the "aperture plate"), or new tension plate, or springs, or all of them.

Wear can be reduced and the machine will pull easier on the handle if the film gate and tension plate surfaces, which are rubbed by the film, are kept free from any gelatine which may come off of the film. Clean them every time by wiping before threading up the new reel, and by wiping with an oily rag every time a new reel is put in—the rag should be oily but so dry that it is not running oil when squeezed in the hand. Never oil them with an oil can.

FILM SHIFT OR INTERMITTENT MOVEMENT

There are many variations in devices for stepping the strip of film forward the three-quarters of an inch from one picture to the next of the series. The requirement of such a device is very severe, for the step must be made with great speed and with great accuracy, and furthermore the film must be permitted to remain perfectly motionless during the interval between steps. A class of projectors, which does not use the intermittent movement, will be considered in connection with continuous projection devices.

The different mechanisms for making the shift of the film upon the step-by-step principle are: the sprocket; the pin; the claw; the beater; and the intermittent grip.

Intermittent Sprocket. The intermittent sprocket is a wheel with two circles of pointed teeth spaced a trifle more than 1 inch apart upon the surface of a drum about 1 inch in diameter, or spaced upon two hubs or bosses to hold them at that distance, the metal being cut away to render the wheel light of weight and easily started and stopped. The sprocket teeth are spaced so as to engage the perforations of the edges of the film strip, and the film is advanced step by step by turning the sprocket wheel intermittently, usually one-quarter of a revolution for each step of the film.

For turning the sprocket wheel in its intermittent motion, a large variety of devices have been employed, and a new one is brought out occasionally. The only test for a new intermittent movement is the test of time. Nearly all intermittents ever used have given place to the Geneva, which was among the earliest of them all.

Geneva or Pin=and=Star. The Geneva movement comprises a star wheel shaped like a modified Maltese cross and attached to the sprocket shaft, and a pin wheel which revolves steadily. Every time the pin comes around it catches a wing of the Maltese cross and throws the cross around one-quarter of a turn, leaving it there until the pin comes around again.

A Geneva movement—it is called *Geneva* because it was used first in Geneva, Switzerland, in watches, with one of the wings of the cross convex instead of concave so that the main spring of the watch could not be wound too far—is shown in perspective view in Fig. 9. At the left is the star wheel, with four slots and four wings each having a concave outer face, as indicated at *A*. The pin wheel is seen at the right, and consists of a flat disk or face plate carrying a pin *B* and the cam band *C*. The cam band is cut away on both sides of the pin and the pin is set outside of the cam band circle, or a little farther from the center hole of the disk. When the pin wheel revolves, toward the left, say—although it depends upon the particular projecting machine or camera inspected, for the Geneva movement may be on either end of the intermittent sprocket shaft—the pin moves toward the left and when the pin comes to the star wheel it enters the open end of the slot next to the wing which has been against the moving cam band; but the cam band now has released that wing and the pin in moving into the slot presses against the side of the wing and turns the star wheel as two meshing gear wheels would turn each other, except that the pin starts the star wheel slowly, swings it rapidly during the middle portion of its movement, and again slows it up to a standstill before leaving the slot. The pin enters the slot, which is shown diagonally upward to the right, and having turned the star one-quarter of a revolution the pin leaves the same slot diagonally downward to the right, the cam bend having come around following the pin to engage the concave surface of the next wing before the pin has left the slot entirely.

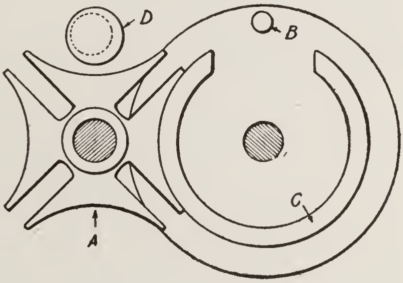


Fig. 9. Geneva Intermittent Movement

The advantages of the Geneva movement are: (1) It starts the film with a slow movement, increasing the speed to a maximum, then decreasing the speed until the film comes slowly to rest. (2) It holds the film or sprocket firmly locked during the interval of rest between shifts. (3) It is very easy in the wear of the sprocket holes of the film because of the lack of jerk in starting the film. (4) It is very gentle with weak or injured places in the film which might yield and permit the film to be torn apart if suddenly jerked. (5) It is capable of construction in such proportions that any desired ratio of time of movement as compared with time of rest may be attained.

To change the ratio of movement and rest of the sprocket wheel and film, the relative diameters of the two wheels are changed. With a larger diameter of pin wheel, the breadth of the wing surface *A* which rests upon the cam band will be a smaller part of the whole circumference, hence the pin *B* must affect the shift of the star wheel, sprocket, and film during a smaller proportion of its total travel, or of one revolution. The ratio between the diameters of the two wheels determines the ratio of movement to rest, the ratio of rotation being four of the pin wheel to one of the star wheel in any case, regardless of the relative diameters of the wheels.

Double Star. The double star movement consists of two Geneva movements working in the same machine, one above the film gate and one below the film gate. The theory is that they assist in keeping the film flat by keeping it taut between them, also that they reduce the strain upon the film by giving the lower sprocket less pulling to do. This mechanism sometimes operates both star wheels from one pin wheel, in which case there are two pins in the pin wheel, the two pins operating the two stars simultaneously.

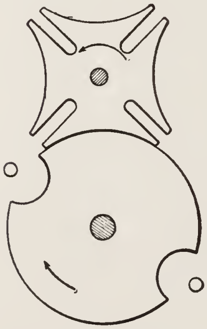


Fig. 10. Double-Pin Geneva Intermitten Movement

Double Pin. The double pin movement is merely a modification of the Geneva movement by which the star wheel takes a step every half revolution of the pin wheel, instead of every full revolution. It is shown in diagram in Fig. 10. The only advantage urged is that the speed of the pin wheel is reduced to half that required were the single pin used. The simple Geneva is the more widely adopted.

Pitman. The pitman movement is illustrated in Fig. 11. The intermittent sprocket is carried by the shaft carrying the ratchet wheel *R*. Since the ratchet in the figure is shown with seven teeth, the sprocket attached would require twenty-eight teeth to feed the standard four-hole film. The wheel *C* is the constant drive, and the face of the wheel *C* carries a wrist pin driving a pitman bar, which in turn drives the pawl engaging into the ratchet R. The pawl upon the top of the ratchet R prevents return of the ratchet during the return stroke of the pitman and driving pawl. As the wheel C may be designed to drive the pawl over a greater stroke than the distance between two ratchet teeth, this device also may have a designed ratio of time of movement to time of rest; unless the movement is approximately half-and-half the start of the film will be a sudden jerk.

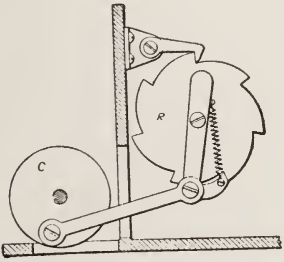


Fig. 11. Pitman Intermittent Movement

Ratchet. The ratchet movement is illustrated in Fig. 12. The sprocket wheel is attached to the same shaft as the ratchet wheel M and the ratchet-shape wheel N is driven steadily. The wheels move in the same direction, as is indicated by the arrows, and they are connected by a volute spring. With six teeth in the ratchets, the sprocket would have twenty-four teeth for a standard film. The pawl N swings upon a fixed pivot and engages both of the toothed wheels. Its function is to hold the intermittent wheel M at rest until the pawl is lifted by the steady drive N, at which time the pawl slips the tooth of the intermittent, but in turn slips a tooth of the steady drive so soon thereafter that it drops toward the intermittent wheel to engage the next tooth of that wheel and to hold it at rest until the next release, as compelled by the steady drive N. The film is started by this mechanism gently by the power of the spring connecting the two wheels M and N, but it is brought to rest with a jerk by the engagement of the intermittent wheel M with the pawl P.

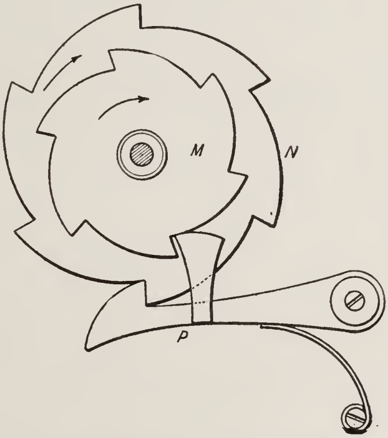


Fig. 12. Ratchet Intermittent Movement

Drunken-Screw. The drunken-screw intermittent movement involves a mechanism which is substantially a worm and wormwheel, but the worm, instead of being inclined through its full length, is straight for the greater part of the circumference and then has a sharp angle. The wormwheel, therefore, stands at rest during the passing of the straight portion of the worm thread, and moves rapidly during the passage of the inclined portion of the thread. The wormwheel, which is shown at *K* in Fig. 13, is attached to the intermittent shaft, and the drunken screw or worm *G* of that figure is steadily driven.

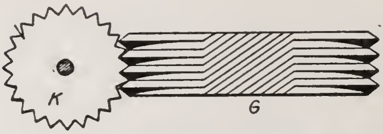


Fig. 13. Drunken-Screw Intermittent Movement

Snail. The snail intermittent movement comprises two wheels normally out of engagement, one of which engages a projection of the other with an inclined edge which propels the companion wheel through a required angle. This movement is shown in Fig. 14. The intermittent wheel *P* is provided with a number of pins, and the snail *S* engages a pin at every revolution and forces the intermittent wheel *P* through the desired angle.

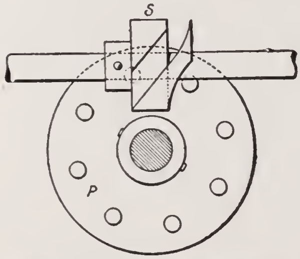


Fig. 14. Snail Intermittent Movement

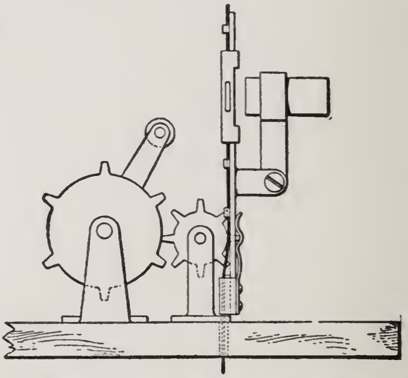


Fig. 15. Spring-Latch Intermittent Movement

Spring Latch. The spring latch intermittent movement has as its distinctive feature the holding and centering of the sprocket for each film picture by means of a bent spring which engages either one tooth, by a notch in the face of the spring, or two teeth of the wheel, by dropping between them with two inclined faces. When

SCENE FROM "COMRADES," BY ECLIPSE
A Military Drama of Strong Moral Tone
Courtesy of the *Kleine Optical Co., Chicago*

such a wheel is pushed over the apex of the spring it is propelled by the spring to its next position of rest and held there until again propelled by the steady drive. Such an intermittent movement is shown in Fig. 15. The smaller wheel is the film sprocket wheel, or fixed to the film sprocket shaft, while the larger wheel propels it intermittently, making a step every time a tooth of the large wheel engages a tooth of the small wheel.

Single-Sprocket. The single-sprocket intermittent movement is shown in Fig. 16, which really is a revolving claw movement. The sprocket wheel moves with steady rotation and has two pairs of teeth. As the first of these pairs of teeth swing against the film, they engage the holes in the edge of the film and drag it down, leaving the film unengaged until the other pair of teeth come into engagement for the next shift.

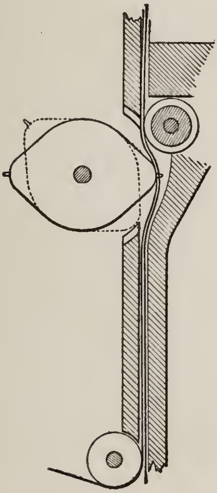


Fig. 16. Single Sprocket Intermittent Movement

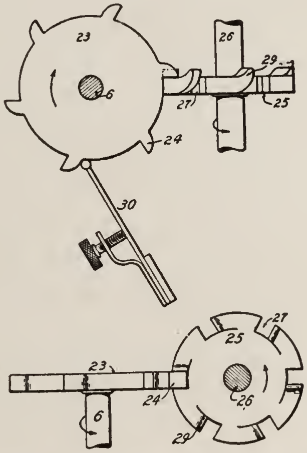


Fig. 17. Modified Drunken-Screw Intermittent Movement, End and Top Views

Modified Drunken-Screw. A modified drunken-screw intermittent movement is shown in Fig. 17. The intermittent wheel *23* tends to move by friction clutch from the main drive, in the direction of the arrow. It is prevented from movement, however, by the engagement of its teeth *24* with the face of the steady drive wheel *25*, which has the upwardly turned wings *29*. The steady drive shaft is *26*, the intermittent shaft is *6*. The spring *30* holds the wheel *23* against the face of the wheel *25* and prevents backlash, locking the film steady during the intervals of rest. When the next tooth *29* of the wheel *25* comes to the tooth of the wheel *23*, the wheel *23* is started with a blow and travels under its friction clutch until the next tooth engages the face of the wheel *25*. Fig. 17 shows a view of the face of the intermittent wheel *23* and the edge of the steady drive wheel *25* in the upper drawing, and the edge of the intermittent wheel *23* and the face of the steady drive wheel *25* in the lower drawing. The arrows show the direction of rotation.

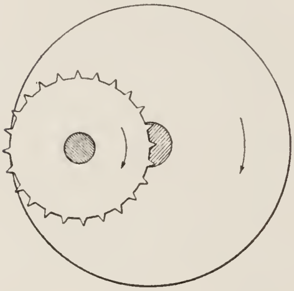


Fig. 18. Eccentric Sprocket or Epicycloidal Intermittent Movement

Eccentric Sprocket. If the lower sprocket-roller of a machine revolves continuously on a fixed axis, it will, of course, continue to draw down film. If, however, it is mounted so that while it revolves its axis also rotates eccentrically about a radius equal to the radius of the sprocket, the film will be moved intermittently, the sprocket simply rolling up along the film for part of a revolution without moving it. Fig. 18 shows its arrangement as it is used in the Prestwich camera. The sprocket is driven by a train of gears.

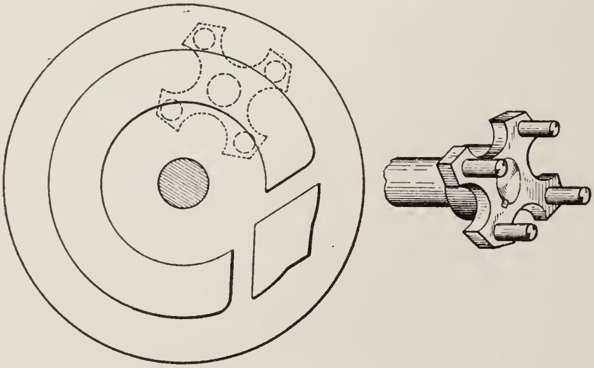


Fig. 19. Pin-Cross Intermittent Mechanism

Pin=Cross. The pin-cross intermittent mechanism shown in Fig. 19 has been offered lately. Its construction seems to indicate strength; the design of the cam band indicates that the shift is made in a very small proportion of the total time of revolution. It is, therefore, a movement bearing promise, to be proven by use. The movement is so new that it still lacks an accepted name, but the name pin-cross seems to be descriptive. In this movement, the member shown separated at the right, consisting of a cross of four arms, each of which bears a pin, is the member attached to the intermittent sprocket shaft. Thus attached, it meshes into the cam wheel at the left, as shown in dotted lines. When the broken or active part of the cam band reaches the pin-cross, the slight projection upon the outer edge of the small cam between the ends of the band throws the leading outside pin outward, drawing the leading inside pin into the slot before the end of the cam band, the following outside pin also taking the cross path after the end of the cam band, the following inside pin becoming the leading inside pin and the leading outside pin becoming the following outside pin. Thus, the pin-cross is turned one-quarter of a revolution, to shift the film, and is held rigid by engagement with the cam band at four points, by the four pins, until the cam wheel has completed another revolution and has come to the point for initiating another shift. Silence is one of the claims for this new movement. It is used on the Power's Cameragraph No. 6, which is advertised to give the complete film shift in one-ninety-sixth of a second, giving the complete shift of the film in one-sixth of a picture interval and running sixteen pictures per second, if desired.

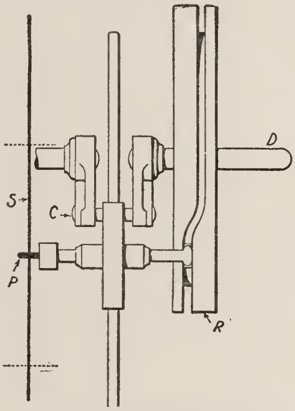


Fig. 20. Theory of Pin Intermittent Movement

Pin. Pin intermittent movements are those in which the teeth engaging the holes in the film are not the teeth of a sprocket wheel, but are teeth fixed to some reciprocating member which gives them the four movements necessary to control the film with pins, namely, (*1*) to advance the pins into the holes of the film, (*2*) to move downward, dragging the film, (*3*) to withdraw the pins from the holes in the film, and (*4*) to return to the point of starting in readiness for advancing into the next holes of the film to repeat the cycle.

Fig. 20 shows the theory of such a film movement. The pins *P* are carried vertically by the action of the crank *C* of the steady drive shaft *D*, which shaft carries also the cam wheel *R* in the edge of which is a groove which controls the pins *P* for their lateral movement, advancing them into the film holes and withdrawing them as required. The slot of the cam wheel *R* is straight except in two places, for advancing and retreating the pins, one of the inclined places of the cam slot being shown in the figure just above the level of the pins *P*. The adjustment of the cam wheel *R* and the crank *C* with angular relation to each other is such that the pins *C* are shoved into the holes of the film by the cam wheel *R* just as the pins come to rest at their upper limit of movement, and they are withdrawn just as they come to rest in their lower limit of movement. The time of motion of the film is, therefore, just one-half the total picture time, the film remaining at rest during the remaining half of the picture interval.

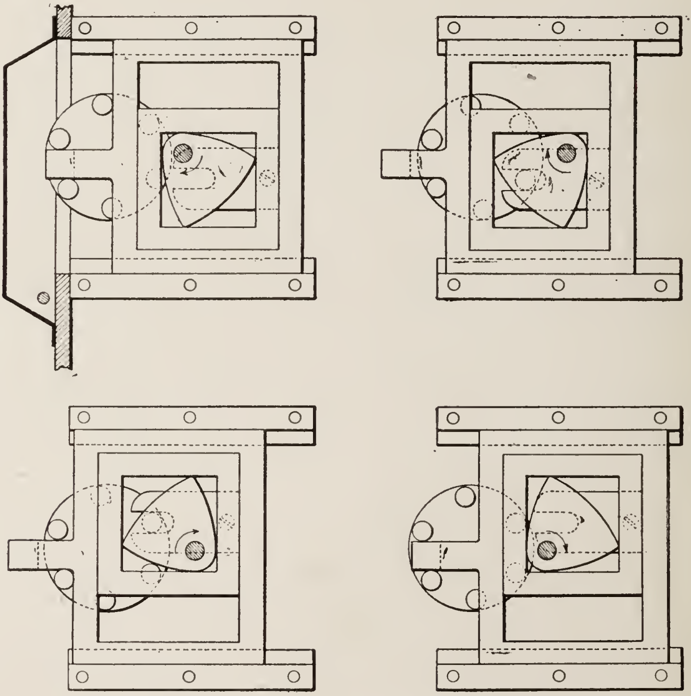


Fig. 21. Pin Intermittent Movement Taking the Four Movements from One Cam

Another design of pin movement, suitable either for the direct action of the pin upon the film or for action of the pins upon a sprocket shaft for intermittent sprocket motion, is shown in Fig. 21, which illustrates the device in four of its positions of operation, and shows it equipped for driving a sprocket shaft intermittently. The sprocket shaft, or intermittent shaft, is shown with six pins, and the teeth of the intermittent driving movement are shown near the middle of each of the figures. The triangular cam is the steady drive member of the device, and it has such form that it fits the four sides of the square surrounding it at all times. In the upper left-hand drawing, the teeth are withdrawn from the pin of the intermittent wheel; in the upper right-hand drawing, the triangular cam has turned and has advanced the teeth to enclose one of the pins upon the intermittent wheel, which as yet has not been moved; in the lower left-hand drawing, the triangular cam has moved further and has lifted the teeth enclosing the pin of the intermittent wheel, thereby driving the intermittent wheel through one-sixth of its revolution; in the lower right-hand drawing the triangular cam has moved further and has withdrawn the pins from engagement with the pin of the intermittent wheel, and is in readiness to be lowered into the position shown in the upper left-hand drawing, to repeat the cycle.

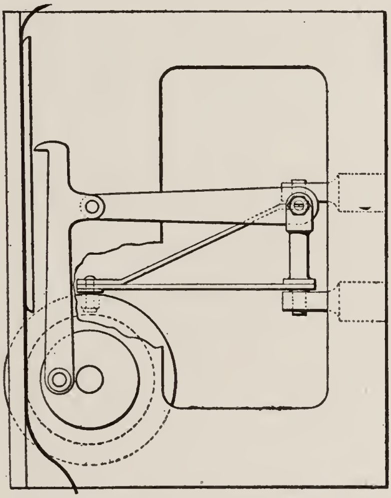


Fig. 22. Pin Intermittent Movement from Two Cams

Another type of pin movement is shown in Fig. 22, where the action is attained by two cams. The pin pair is located at the top of the vertical lever upon the wrist pin, which drives it vertically as a pitman rod, but at the same time the top of the vertical pin lever is rocked to the right and to the left, as viewed in the figure, by the arm which is attached to it near the pins at the top and which passes to the right. By means of this auxiliary cam connection, the pins are advanced into the film holes when the lever is at the upper limit of its stroke and are withdrawn when it is at the lower limit.

Still another type of pin movement acting directly into the film holes is shown in Fig. 23. The two cams are upon one shaft, one, a triangular cam, providing for the vertical movement, and the other a circular cam, providing for the movement toward and from the plane of the film. These cams take the proper angle on the shaft to provide for inserting the pins into the film holes while the pins are at rest in their vertical movement.

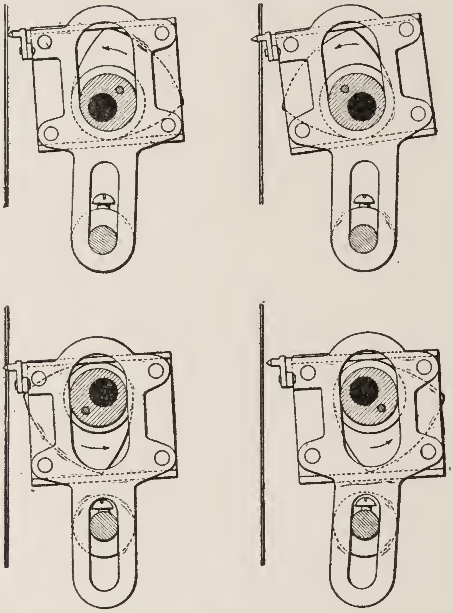


Fig. 23. Pin Intermittent Movement Taking the Four Movements from Two Cams on the Same Shaft

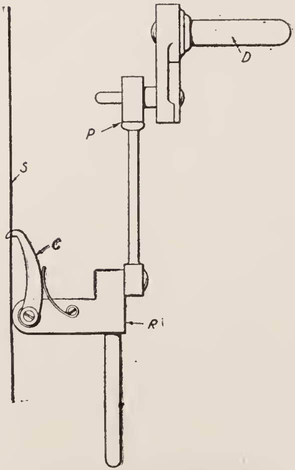


Fig. 24. An Intermittent Mechanism Built Upon the Claw Principle

Claw. The principle of the claw intermittent movement is shown in Fig. 24. In this figure, *S* is the film with perforated edges, preferably only one hole per picture; *D* is the steady drive shaft, *P* a pitman rod, *R* a reciprocating frame carrying the claw, and *C* the claw itself. The operation is merely that of a pawl upon a rack or ratchet, the film being the ratchet or rack and the holes being the spaces between the teeth for the claw or pawl to engage. As the pitman rod draws the reciprocating frame up, the claw rides on the edge of the hole until lifted out of the hole, then it rides upon the film under pressure of its spring until it reaches the next hole, when it drops in. When the pitman then drives the reciprocating frame down, the claw drags the film down, and again rides up to the next hole.

The pin and claw movements both are very severe in wear upon the holes of the film. They are suitable for cameras where the film is passed through the machine but once; frequently they are found on projecting machines of an older type.

Beater. The principle of the beater intermittent movement is that the film shall be taken up constantly, and at a constant rate, but that there shall be a definite amount of slack pulled through the film gate into a lower film loop just below the film gate, this slack being pulled through once for each picture interval, to shift the picture in the film window. The amount of slack in the film loop between the film gate and the steady drive take-up wheel shall be greater than the picture length of the film, so that the take-up wheel never pulls directly upon the film at the film gate but acts only to

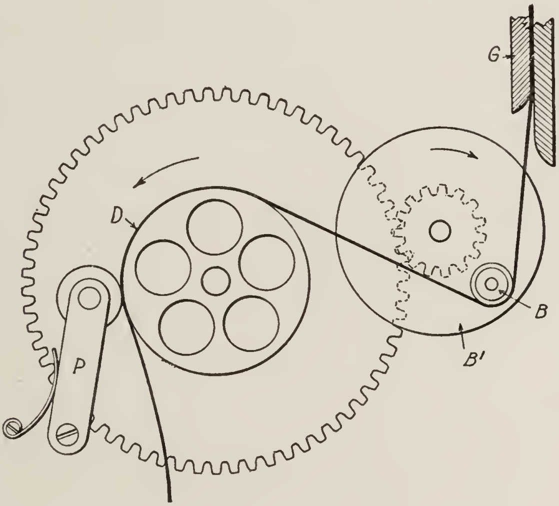


Fig. 25. An Intermittent Mechanism of the Beater Type

take up the slack pulled in by the beater. The beater may be a wrist pin upon a face plate, or it may be a spring-propelled or pitman propelled device, or any reciprocating part whatsoever.

Wrist-Pin Type. The wrist-pin type of beater intermittent movement is shown in Fig. 25. The steady drive wheel is shown as a drum at *D* with the presser roller *P*. The beater pin *B* is upon the face of the wheel *B′* and the wheels *B′* and *D* are geared together by a pair of spur gears. As the pin *B* passes over the top of its travel, the wheel or drum *D* takes up the slack between *D* and *G*, or takes up a definite measure of the slack, although perhaps not all of it. Then as pin *B* passes downward it pulls upon the film and draws through the film gate *G* just as much as has been taken up by the drum *D* since the last pull. The amount of film pulled through the film gate *G* does not depend upon the size, character, position, or radius of rotation of the beater pin *B*, but does depend upon the amount of rotation of the drum *D*, or the amount of lineal travel of the surface of the drum *D* for each revolution of the beater pin *B*.

Pitman Type. The pitman type of beater, illustrated in Fig. 26, shows the beater mechanism alone. The film *S* is shown as a heavy line from top to bottom of the figure, bent between the two fixed studs, *A* and *C*, which may be merely idler rollers, by the thrust of the beater roller *B*. The beater roller *B* is carried upon the pitman rod *D* which is driven by the crank *E* upon the steady drive shaft *F*. The film gate of the figure is assumed to be above the mechanism of the figure, and the steady drive take-up device is assumed to be below, taking up between shifts the slack pulled into the film by the beater roller *B*, or at least a part of that slack. In this device, as in all beater devices, the amount of film drawn into the film gate by the action of the beater roller is not dependent upon the characteristics of the beater roller or of the fixed studs co-operating with it, but depends solely upon the amount of film travel over the take-up drum during a single revolution of the steady drive shaft *F*.

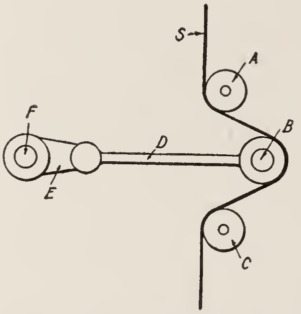


Fig. 26. The Pitman Type of Beater Intermittent Mechanism

Spring-Bar Type. The spring-bar beater is still another type of beater intermittent mechanism. It consists of a beater roller mounted upon a spring-pressed bar, which bar is restrained by a ratchet mechanism until the shift is desired, when it is released to strike the film so as to draw the slack into the film loop, being immediately picked up by its restraining mechanism again, and again held until the instant of the next shift.

Intermittent Grip. The intermittent grip mechanism, shown in Fig. 27, is in a class by itself, but never has come into general use. It operates without perforations in the film. The two wheels revolve toward each other, and when the enlarged places meet with the film between them, the film is gripped and drawn downward through the film gate. The amount of film pulled at each such meeting, that is, at each revolution of the pair of grip wheels, depends upon the length of the gripping surfaces which meet each other. Framing is accomplished by shifting the rollers slightly so that their ends overlap, the extending ends not being effective in pulling the film, and thus reducing the amount pulled.

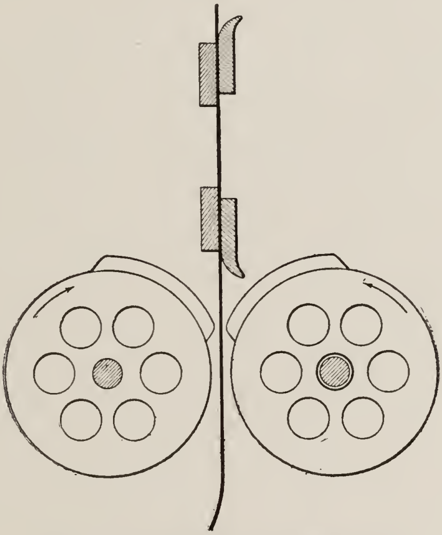


Fig. 27. Intermittent Grip Mechanism

For the greater part, all mention of intermittent mechanisms other than the intermittent sprocket feeds are historical, the sprocket being almost universal at the present time for projecting machines; many of the variations in intermittent mechanisms, and particularly in pin mechanisms, are found in cameras for taking motion pictures.

Adjustment of Intermittent Movements. The customary adjustment provided for the intermittent movements for taking up wear between the wheels or cams is the eccentric bushing. This bushing, which is included as a part *D* of Fig. 9, is placed in the hole in the frame through which the drive shaft of the intermittent movement passes, and the drive shaft itself passes through the hole in the bushing, indicated by the small dotted circle. By turning the bushing slightly in the frame, the position of the drive shaft is changed very slightly as compared with the movement of the bushing, and a very accurate adjustment is possible. The cams should be adjusted when properly oiled with a medium heavy oil—a very light oil will not stay on the cams and a very heavy oil is too sticky for the rapid cam motion. If adjusted dry, there will not be room for the oil to work between the cam surfaces without making the adjustment too tight, and if adjusted with a surplus of oil the oil will work away and leave them loose. The adjustment of the cam band of the pin wheel and the concave wing of the star wheel must be very accurate or the picture will lose its steadiness on the screen, taking a slight vertical jiggle. Many Geneva movements are fitted with an oil box or tank and run immersed in oil.

The pin and claw movements must be kept carefully adjusted, particularly as to those cams which give the film the vertical movement. The film teeth of these mechanisms wear rapidly and should be examined frequently and replaced when wear is detected.

In the beater type of mechanism, the beater roller usually is cut away in the middle and strikes the film only on the edges, outside of the picture space. With rollers thus cut away in the middle, the remaining bosses which strike the film are likely to become worn conical, tapering toward the inside, resulting in irregular action of the film and consequent jiggling on the screen. In addition, a worn beater roller wears the film by bending it.

The edges of the celluloid film in the holes engaged by the sprocket teeth or pins or claws are sharp and hard enough to cut away the teeth which grip them and particularly because of the rapidity and of the almost innumerable times that the film is gripped, pulled, and loosened in the course of a few months' use of a projecting machine in a theater. Wear of the teeth engaging the film acts upon the film, for the teeth wear into a hollow on the pulling face, making the point of the tooth of slightly hooked shape, and these hook teeth pull against the edge of the holes and tend to tear the film as they leave it. Worn teeth must be watched for and replaced when noticed.

Sprocket wheels are interchangeable, and new ones can be bought from the projection machine makers and placed on the motion head with little trouble, or new rings of teeth can be bought and placed upon the old sprocket drums or bosses. Some types of sprockets are especially constructed with interchangeable teeth, and new tooth rings may be bought at a very low price to replace the worn ones.

In addition to watching for wear and loose adjustments, the moving mechanism of the intermittent and all other parts of the motion head should be cleaned periodically, say, every two months if the machine is running evenings only and is giving no trouble, and every two weeks or every month if the machine is running all day, even though giving perfect service, and with no indication of trouble. Wipe off all oil, and empty the oil bath of the intermittent movement if it has one. Run the intermittent tank full of gasoline and turn the machine for a while to work it thoroughly through the cams; of course it will work out through the journals of the oil box and wash those clean. Wipe it off as it comes out, using a clean rag. Next, the mechanism should be oiled liberally with a very light oil to wash out the residue of the evaporated gasoline, and this light oil then should be followed with the standard body of oil regularly used on the machine. The gasoline (or even kerosene) loosens the dirt, the light oil carries out what the gasoline left by its too rapid evaporation, and the journals then are clean and ready for their standard working dose of regular lubrication. Do the same for all of the journals, putting oil in the oil holes with a can spout and wiping it off as it runs through—first gasoline, then very thin oil, then regular lubricator—loosen the dirt, wash it out, then oil up for service. The toothed surfaces of the gear wheels should be cleaned in the same way, for they pick up grit very freely. If after cleaning the gear wheels they rattle a little, wipe them as dry as possible and hold a lump of beeswax against the teeth and turn the handle of the motion head through several revolutions. This will quiet the noise without injuring the gears.

CONTINUOUS PROJECTION

Any system which will keep the illumination constant upon the screen will be independent of the disadvantages of flicker, and possibly other disadvantages may be avoided or disadvantages obtained by devices designed to project the second picture upon the screen before the first is removed, as with the dissolving lantern.

Four methods of attack, none of which has come into general use, have been used for this problem, viz, duplex projection, moving lenses, moving mirrors, and moving prisms.

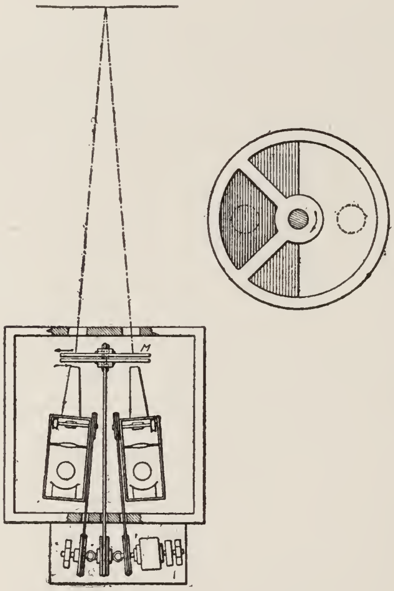


Fig. 28. Duplex Projection

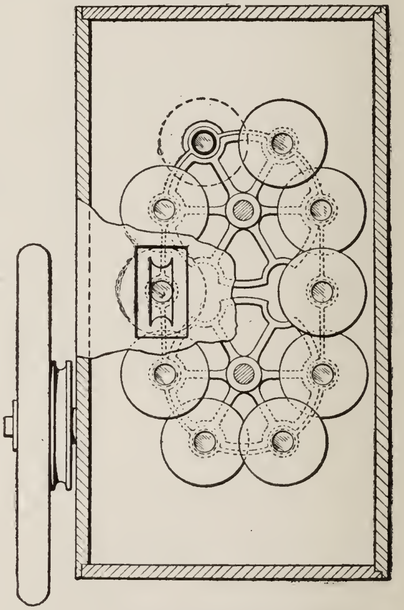


Fig. 29. Continuous Projection by Moving Lenses

Duplex Projection. Duplex projection consists of projecting from two lanterns with a dissolving shutter, each change dissolving from the old picture to the new, and each lantern shifting its film to the succeeding picture while the viewing screen is under full illumination from the companion lantern.

The arrangement of the two lanterns driven by one motor is shown in Fig. 28, the lanterns indicating by the dotted lines that the central rays projected reach the same point upon the picture screen. At the right of the lantern diagram is seen the front view of the before-the-lens shutter *M* which is placed between the two lanterns and acts as shutter for both of them. The white half is the open half, the dark quarter is opaque, and the remaining portions are semi-transparent. These semi-transparent portions of the shutter extend the dissolving of the view and make it a little softer than a simple half-and-half shutter would give.

Moving Lenses. Moving lenses for continuous projection are shown in Fig. 29, which is a front view of the projecting machine. The lenses of the chain are spaced $\frac{3}{4}$ inch apart—just picture distance—and each of them follows a picture down as the film passes with steady motion through the film window, which is nearly as long as two pictures. There is no intermittent mechanism in this projector. The middle lens at the left of the chain is shown in the middle of the projection window, and as the lens now visible through that window passes downward with its film image, the next lens will approach the projecting window from the top. The top and bottom edges of the projecting windows are substantially shutter edges, and as the following lens comes into action at the top of the window, the preceding lens will go out of action by passing behind the lower edge of the window. Thus, a dissolving effect is secured, and continuous illumination of the screen is effected, changing the images without intermittent mechanical motion.

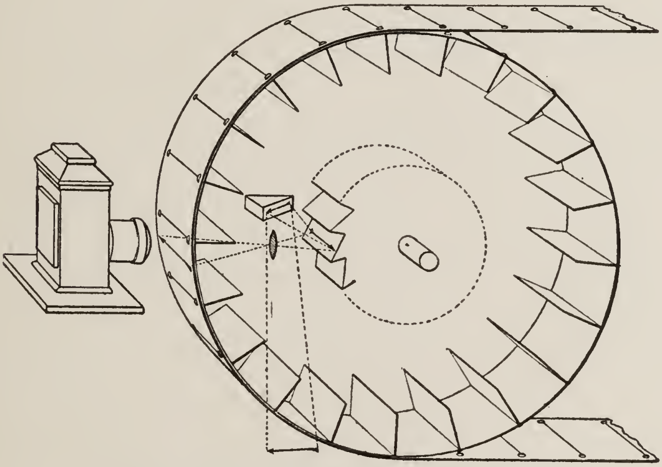


Fig. 30. Continuous Projection by Moving Mirrors

Moving Mirrors. Moving mirrors for continuous projection are shown in diagrammatic perspective in Fig. 30. The large wheel is a wheel of shutter leaves, carrying the picture film upon its surface, or upon the edges of the shutter leaves which form a series of windows over which the pictures of the film are stretched. In the center of the wheel is a drum of mirrors which is arranged to turn at half the speed of the drum of shutters carrying the film strip and pictures. At the left is the lamp house and the dotted lines show the course of the beam of light from the lamp house through the condensers in the front of the house, through the film, through the single lens to the drum of mirrors, then to a fixed mirror and then downward, whence the beam carries to the picture screen. Again there is a continuous illumination of the screen without any intermittent mechanism. Two mirrors of the drum in the center always will be working in the beam of light between the lamp house and the screen, one mirror projecting the upper and the other the lower portion of the picture seen upon the screen, except at the instant when one mirror ceases and another begins the projection.

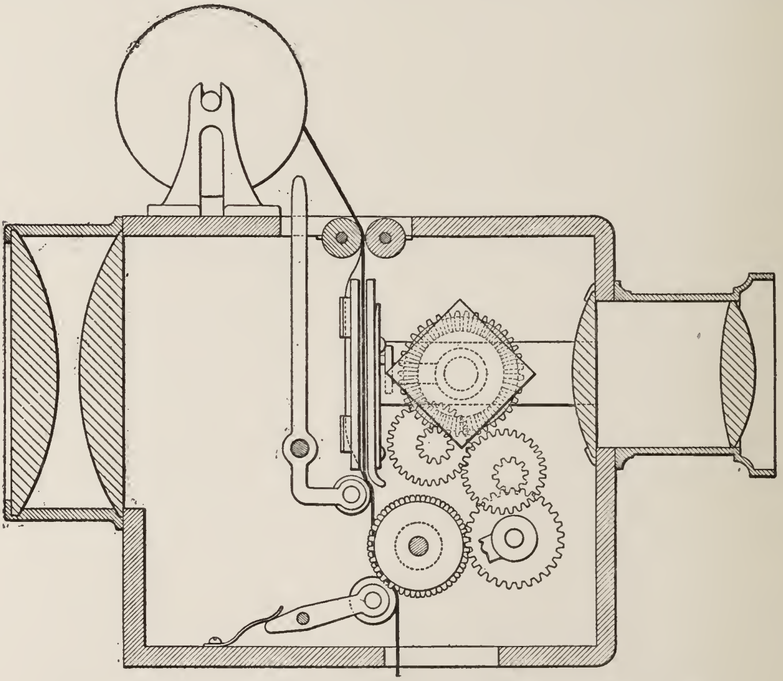


Fig. 31. Projecting Machine for Continuous Projection by Moving Prism

Moving Prisms. Moving prisms for continuous projection are shown in Figs. 31 and 32. Fig. 31 shows the diagram of the complete projecting machine from condensers to objective lens, and Fig. 32 shows two diagrams disclosing the course of the rays forming the beam of light through the film, prism, and objective lens. No intermittent mechanism is used.

Steady Feed Elements. The motion head projecting by intermittent motion of the film is provided with two elements of steady feed for relieving the film from the jerk of the intermittent as far as possible. If the intermittent feed were required to pull the film from the feed reel, turning the reel in so doing, and if also the take-up reel were allowed to pull directly upon the teeth of the intermittent sprocket, the wear upon the film and upon the sprocket would be great. This is much reduced by providing upper and lower steady feed sprockets, relieving the intermittent mechanism from all duty but the shift of the short piece of film in the film gate, the film being brought from the feed reel down to the upper end of the film gate by the upper steady feed sprocket, and being held slack below the intermittent and fed to the take-up reel under proper tension by the lower steady sprocket. In order that a proper looseness of film, or slack to avoid strains, may be had above and below the intermittent feed, the film is formed into slack bends which are known as *upper feed loops* and *lower feed loops*.

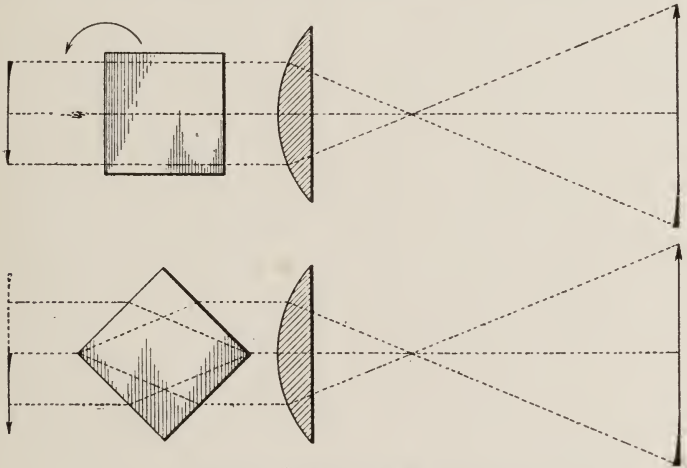


Fig. 32. Diagrams of Course of Light Rays in Continuous Projection by Means of Moving Prism

THREADING UP THE MOTION HEAD

The course of the film through the motion head, the elements which operate upon it, and the method of placing the film in position may be studied at the same time, taking the steps in the order in which they are encountered by the film in its travel.

Feed Reel. The feed reel is a spool upon which the picture film strip is wound when ready for projection. It consists of a core from 1½ to 2½ inches in diameter, with a spring clip for taking the end of the film which is to be the inside end of the reel; the reel then is turned and the film is wound upon it, a strip of 1,000 feet of film filling the reel to a total diameter of about 10 inches. The 10-inch reel has upon its core two sheet-metal flanges equivalent to spool ends, which are about 10 inches in diameter. Winding the spool full of the film to be projected, beginning with the "end of the picture" or "tail" of the film, and finishing with the "title" of the picture or "leader" of the film upon the outside of the spool, is called *rewinding*, and when so wound, or rewound it is ready to be placed in position.

Feed=Reel Magazine. An iron fireproof box with a fire-trap film outlet is provided for receiving the feed reel. The feed reel, in response to the pull upon the film by the upper steady feed, turns loosely in this fireproof magazine. Place the full feed reel in the upper magazine, start the lead end of the film through the film outlet at the bottom of the feed magazine, just above the motion head, and close and fasten the feed magazine door. The feed reel is shown without its fireproof magazine at *1* in Fig. 33.

Upper Steady Feed. The lead end of the film is pulled out about 3 feet, the presser roller is lifted from the upper steady feed sprocket and the film is laid upon the surface of the sprocket drum with the teeth of the sprocket passing properly through the holes in both edges of the film. The presser roller is dropped upon the drum with its spring, or there may be two such presser rollers, or an idler roller between the upper feed and the feed reel. In Fig. 14, an idler roller is shown at *2* to direct the film to the upper steady feed sprocket *3* at the top of the sprocket so that the film will wrap a full half-way around the sprocket and get the benefit of a pull by a large number of the sprocket teeth. The presser roller—or friction roller as it is sometimes called, though friction is no part of its function—is shown by the small circles just below the sprocket *3*, not numbered.

THE YOUNG SAILOR PUTS FATHER TO WORK
Scene from Photoplay, "Taming a Tyrant"
Courtesy of *Essanay Film Mfg. Co., Chicago*

Upper Feed Loop. The film is formed into the upper feed loop before passing to the film gate, that is, the film gate is opened and the film is placed in the groove of the body of the gate, the film being lifted from 2 to 6 inches higher in the gate than it would be if stretched straight from the top steady feed sprocket to the gate. The film in the gate is carried into engagement with the intermittent sprocket teeth, and the door of the film gate is closed upon it, clamping it in position. The placing of the film higher in the film gate leaves a looseness in the film above the film gate and between the film gate and the upper steady feed sprocket, which forms the upper feed loop, as shown at *4* in Fig. 33. At every shift, the intermittent feed pulls some of the slack out of this loop, and between shifts the upper steady feed feeds the film down to replenish the slack pulled out by the intermittent.

Film Steady Drum. In some motion heads the film is not permitted to feed directly from the upper feed loop to the film gate, but is taken over a drum which guides it into the entrance to the gate. This film steadier is shown at *5* in Fig. 33, and its presser roller is shown by the small circles just above the drum *5*.

Film Gate. The film gate is indicated at *6* in Fig. 33. It is of many types, but usually has a door to be opened, and a groove into which the film is laid and upon which the door is then closed.

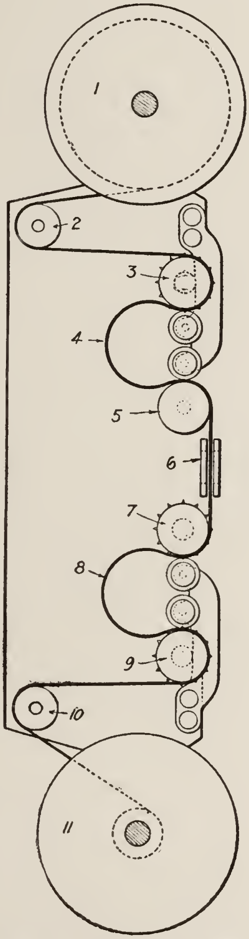


Fig. 33. Diagram Showing Film-Feeding Elements of the Motion Head

Intermittent Sprocket. The teeth of the intermittent sprocket or of the intermittent feed of any type usually are so closely associated with the film gate that they substantially run in the sides of the groove through the body of the film gate, so that at one operation the film strip is placed in the groove of the gate and upon the teeth of the intermittent mechanism. The intermittent sprocket is shown at *7* in Fig. 33, and its presser roller is shown by the small circles just below it.

Lower Feed Loop. The lower loop is formed as the upper loop was, by placing the film upon the lower steady feed sprocket from 2 to 6 inches higher than it would lie if drawn straight from the intermittent mechanism or film gate. The lower feed loop is shown at *8* in Fig. 33. The intermittent pulls three-quarters of an inch of film into this lower loop at every shift of the pictures, thereby increasing the size of the loop, but the lower steady-feed sprocket takes the film up steadily and takes up the exact amount of film before the next shift.

Lower Steady=Feed Sprocket. This sprocket is shown at *9* in Fig. 33, and its presser roller is shown by the small circles just above it. In this figure the presser rollers of the upper steady sprocket and of the friction drum are placed upon the same arm, while the presser rollers of the lower steady sprocket and of the intermittent sprocket also are upon the same arm—this is a matter of preference and convenience for the operator as differently designed by the different manufacturers. The film now is taken over the idler *10* —which is omitted in some motion heads—to the take-up reel.

Take=Up Reel. This is substantially the same as the feed reel. If the end of film leader which was drawn out of the feed magazine to begin threading is not long enough to reach the take-up reel, the handle of the motion head may be given a few turns, feeding the film down. The end is passed into the take-up magazine through the film outlet (which is an inlet this time) and the end is fastened under the spring clip upon the hub of the take-up reel. The slack of the film between the take-up reel and the lower steady feed is wound up by turning the spool itself by hand, then the motion-head handle is given a turn or two with the take-up magazine door open in order to make sure that the take-up is working properly. Then the door of the take-up magazine is closed and you are ready to light up, start the crank, open the fire shutter, and "let 'er flicker"—for slang ceases to be slang when it is simple truth.

The take-up must be watched particularly at the beginning of the film reel, and particularly toward the end of the film reel, when the take-up reel is nearly full, is heavy to move, and moves slowly on account of the long distance around it. The take-up reel moves more and more slowly as the spool gets more and more nearly full, and some compensation is required between the speed of the reel, always varying, and the speed of the driving handle, which is constant. This compensation usually is provided by a friction drive for the take-up reel—perhaps, a pair of friction plates held together by a spring; perhaps, two grooved wheels belted by a belt which is supposed to pull tight enough to pull the heaviest load and yet slip rather than tear the film or stop the operator's arm. These friction devices should be noted and kept in proper adjustment, for a friction device can hardly be expected to stay in adjustment very long, as the plates wear smooth or get grit between them, and the belts stretch. The friction device must drive the take-up reel fast enough to take up the film on its small center when the film is just starting, and must not pull so hard that it will pull the film apart in its weaker spots. Excess friction makes the handle turn harder.

Framing Devices. The word "frame" when applied to the projection of motion pictures refers to the position of the projected image upon the picture screen, or to the position of the film image as related to the film windows. When the top of the picture is at the top of the screen, or at the bottom of the film window, and the picture just fills the screen and the window, the picture is said to be "in frame," the image fitting the film window as the lithograph fits the frame on the cottage wall. When, by reason always of improper adjustment of the film or of the motion head, the top of the picture on the screen is a few inches from the top of the illuminated area upon the screen, and the lower edge of the next picture shows across the top of the picture being projected, then the picture is said to be "out of frame," and when examined in the film window it will be seen that the little image does not register with the window. As films may be defective in median portions, the motion head must be able to frame while running.

Framing is accomplished by shifting the film with reference to the lens or film window. Somewhere about the motion head—and its position and general appearance varies with different makes of machines—will be found a *framing lever.* When the motion head is standing at rest, and when the framing lever is moved, (*1*) the lens and film window will move upward or downward with the film remaining stationary in the gate; or (*2*) the film gate and intermittent mechanism as a whole will move upward or downward, the lens remaining stationary; or (*3*) the intermittent feed alone will move as a whole and will draw the film downward or try to push it upward through the film gate; or (*4*) the intermittent sprocket will rotate a little in one direction or the other, without changing the location of its shaft; or (*5*) a little slack will be taken up or let out in a *framing loop* formed for the purpose of framing, and located between the intermittent feed mechanism and the film window.

Framing is usually and most easily accomplished by looking at the picture projected upon the screen. The picture may be brought approximately to frame by looking at the film window after threading up the head and before beginning projection. The final adjustments, like the final adjustments of focus, should be made by watching the picture screen during projection.

The framing lever always has a movement of more than one full picture. When you try to "frame up" and the lever will not move far enough to frame the picture, then "frame down" nearly a whole picture instead and the proper adjustment can be reached.

Rewinding. When the reel of film has been turned through, the tail end is allowed to run through to the lower steady feed, then is caught and taken back to the feed reel. The main drive handle may have a shift to throw it to a rewind position, or it may have to be removed from the main drive shaft and placed upon the end of a special rewind shaft; in either case, the turning of the handle when changed for rewinding will turn the feed reel rapidly and will wind the film back from the take-up to the feed reel and at a much faster speed than the speed of projection—one to two minutes to rewind a reel which took twenty minutes to project.

The laws of New York and possibly of some other states do not permit the rewinding of film in the projecting room. It must be taken from the projecting machine in the reel and rewound to a feed reel. Two reels mounted edge to edge, near each other, with a crank and gear on one of them, is the rewinding device then used.

Automatic Rewind. Devices for avoiding the rewinding of the film before a second projection have been suggested and tried. Fig. 34 shows a well-known projector equipped with the automatic rewind, or rather with such a relation of take-up and feed devices that no rewind of any kind is required. The feed magazine feeds *from the middle of the roll of film* and the take-up reel rolls the film up with a large center hole, so that the operator may take the roll of film from the take-up magazine, drop it into the feed magazine, start the inner end through the film outlet and thread it through his motion head back to the take-up, and his machine is ready for another projection of the film. Not only does this sort of improvement save the operator's time and labor, but it saves wear on the film, which becomes scratched in rewinding at high speed.

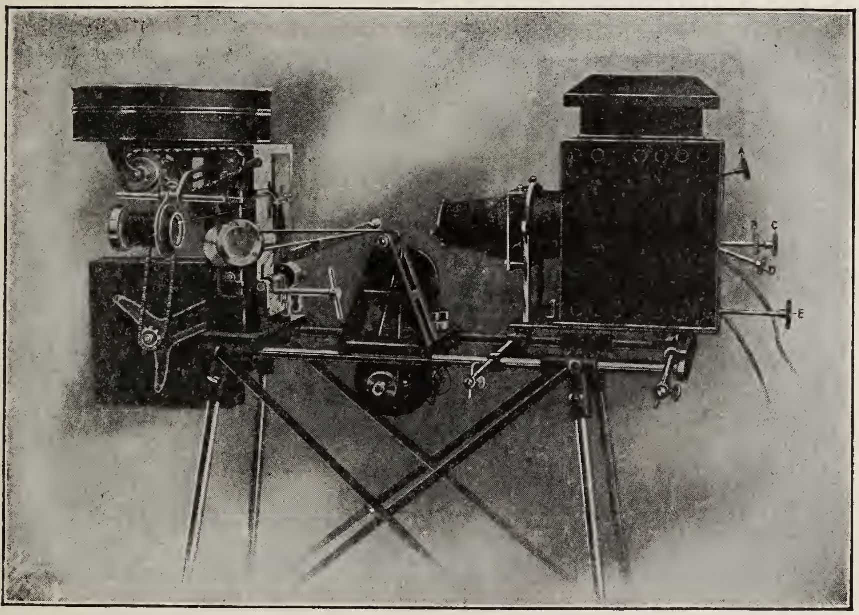


Fig. 34. Projector with Automatic Rewind

Another type of machines joins the leader to the tail of the reel and runs the picture twice or more without stopping, if desired.

No automatic rewinds are in general use in theaters as yet, though the type illustrated in Fig. 34 was widely sold at one time, and the endless belt type is used in penny arcades.

Film Basket, or Molasses Can. The take-up reel goes wrong in operation oftener than any other one part of a projector. Often the operator must stop the show to set it right, and in the middle of a picture reel. A more reliable method is to let the film run from the lower steady feed into a sheet-iron can or box of 2 or 3 cubic feet, folding up loosely as it runs in. It is rewound from this can to the feed reel. Because of the early practice of letting the film run into an open basket, with its comparatively great fire risk, this take-up can is still called a "film basket" by older operators, while it is called a "molasses can" also from the manner in which the film folds down into it. Where the fire ordinances of the town permit it, the can will be found to "give a better show" than the take-up reel; it is less wearing on the operator and on the film.

Operator's Control of the Picture. There are two features in which the operator has control directly for modifying the picture—*speed of projection* and *brightness of light on the screen.* Framing is not a matter of arbitrary control, it is merely a necessary detail which must be kept in adjustment.

The picture may be improved by reducing flicker when possible by reducing the illumination, either by a lamp adjustment if convenient, or by a tinter; preferably the tinter, since by removing the tinter the full illumination is restored immediately when a dense scene is projected in the run of the same reel.

Flicker may be reduced by speeding up the rate of turning, also. In the case of a picture having the upper part of the screen white sky and the lower part dark foreground, the illumination must be retained to make the foreground visible, and the only means for reducing the flicker is speed.

The sentiment of the picture may be watched and speed may be used accordingly, the operator turning more rapidly where he deems the action of the picture could be improved thereby. The manufacturer should have timed his action when making the picture, but sometimes this is neglected.

Motor versus Crank. Most cities prohibit the motor for turning the motion head. The way to keep the operator attending closely to his film is to keep him at the machine turning the crank, hence all other methods of driving the motion head are forbidden. Where the motor is permitted, a small electric motor of the usual fan size, $\frac{1}{12}$ or $\frac{1}{16}$ horse-power, will drive it. In case the motor is used, the film always should be started and turned for 50 feet or more with the crank before the motor is switched on. This gives the operator the "feel" of the machine and tells him whether everything is running as it should. Then the labor is turned over to the motor for the greater part of the run of the reel. Just before the end of the reel the operator should take his crank again and shut off his power, again assuring himself by half a minute of hand turning that his projector is in perfect running order and does not require repairs or readjustment before starting the next reel. The operator's hand upon the crank is the doctor's finger on the pulse of the patient; the slightest irregularities in mechanical action are noted by the "feel" of the handle. The operator's eye must be upon the screen practically all of the time for framing and focus, even if not for flicker.

FILM

Films of all makers for general commercial use are made to about the same size, $1\frac{3}{8}$ inches wide, $\frac{1}{200}$ inch thick including celluloid and gelatine; of this width of $1\frac{3}{8}$ inches, a strip down the middle 1 inch wide is reserved for the picture and the holes are punched in the margins near this strip, $\frac{3}{16}$ of an inch apart. The various makers follow this standard rather loosely, because it is itself rather loosely composed and rather indefinitely expressed. One of the most prominent points of variation is the shape of the hole used; another is the distance between the two rows of holes, or the distance from either edge to the nearest row of holes. A movement is being made to work out a standard, expressed accurately in thousandths and split thousandths of an inch. It is believed that the life of films will be lengthened if all are alike and the projector may then be built accurately to that film size.

Care of Film in Projecting. Fit the film accurately to the sprockets before starting projection. If possible, look through the reel for bad edges, bad splices, or unframed splices before beginning projection, and repair any troubles found. Listen to the purr of the film over the steady feed sprockets and bad places in the sprocket holes will be detected when running. Watch the screen for unframed splices and for focus; a film which runs out of focus for a few seconds at a time and then runs true, constantly varying the focus while the lens and film are unmoved and the film gate is clean and perfect, may be warped; it should be moistened, as discussed under the subject of warped films. If a film rattles as it leaves any of the sprockets, the teeth of the sprocket may be worn into hooks; a new sprocket is the proper remedy.

Care of Film in Rewinding. Rewind under steady tension. Do not rewind loose and then holding the film take up the slack by winding the center of the coil tighter; that grinds into the film any grains of dust which may have been collected and which otherwise might be brushed off. In rewinding, the film may pass over a soft rag, or through a soft rag held bunched in the hand, to wipe off the dust, the first time it is rewound. Particular care must be given to the gelatine side of the film in order to avoid scratching.

Care of Film in Storage. The film should always be packed in metal cans or flat boxes when setting it away. It must not be kept in a warm place as the celluloid will give off explosive gases, the gelatine will dry out and warp the film, and the celluloid will shrink with the heat, particularly if it be an NI (non-inflammable) film.

Care in Handling Film. Do not let the ends of the film become unrolled; they are liable to a sharp bend which leaves a crease and ultimately a break. Keep the roll flat when off the reel. The dropping out of the middle in a cone shape and pushing back again only adds scratches where none are needed. Handle by grasping the flat of the reel which is the edge of the film, and handle as little as possible.

Packing for Shipment. Place the film first in the iron box, then in the wood box, and see that the danger label which the film exchange puts on is still on the outside of the box. In unpacking, see whether the box is fastened with screws, if so use a screwdriver, not a hatchet; and use the same box for re-shipment to the film exchange.

Repair of Films. The usual method of repairing films is to cut out the defective place and splice the ends together, thus reducing the length of the film by the few small pictures cut out with the bad place. Where a crack is seen starting across the film, it is easier to take a piece of clear celluloid film strip from which the gelatine has been soaked and cement ½ inch of it across the film over the crack, than it is to splice it. This is cemented upon the glossy side, leaving the gelatine and the picture image intact, and it saves the order of pictures in the film without causing a sudden jump of the moving characters when the fault is reached in projection. The film thus repaired is no thicker than a splice, and will pass the sprockets and film gate with the same ease. The patch should not be more than one-half a picture in size, or the film will be stiffened more than a splice would stiffen it.

Where the sprocket holes have a bad spot, a piece of blank film (with the gelatine soaked off) may be attached sometimes to avoid cutting out good images.

Film Splicing. Cut one end on the line between pictures; cut the other end with a quarter picture on; thus in cutting a film there will be three-quarters of a picture cut out, a picture and three-quarters, etc. Moisten the gelatine on the quarter picture and scrape it clean: also scrape the celluloid side of the other end clean. Spread cement on the cleaned quarter picture space and put it on the back of the other end, sticking the two ends together with the picture lines matching and with the sprocket holes matching. Cut either through a sprocket hole or midway between sprocket holes, straight across the film. Small scissors are more convenient than a knife.

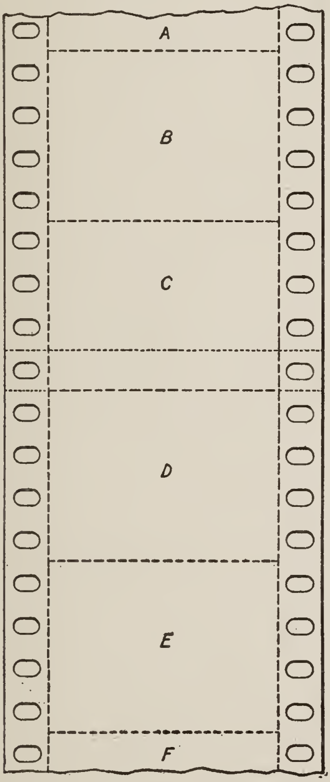


Fig. 35. A Splice "In Frame"

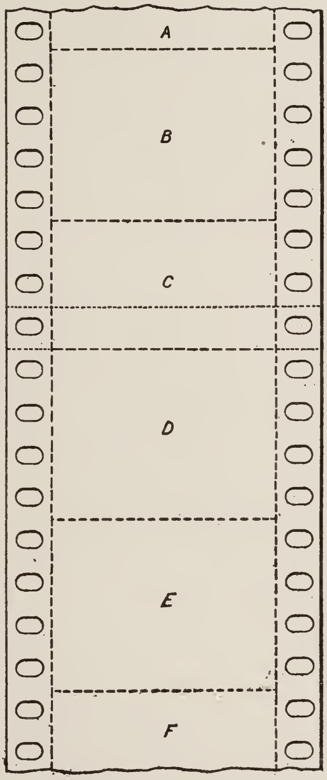


Fig. 36. A Splice "Out of Frame"

Splicing by Machines. A number of forms of splicing machines are offered. All of them have teeth for registering the sprocket holes while the splice is setting, and all of them require special instruction and some skill of hand and common sense. Either with or without the machine, get some scraps and practice on them until you can make it right. Your film exchange or a friend operator will give you a handful of short pieces for practice; and the cement is twenty-five cents for a very small bottle. A flat stick is the best cement spreader.

Non-Inflammable Film. In splicing a non-inflammable film a special cement is required, the NI film cement being suitable for either ordinary film or NI film.

Splicing "in Frame." Splicing a film "in frame" may be understood by a study of the companion figures, Fig. 35, which shows a splice "in frame" and Fig. 36 which shows a splice "out of frame."

In Fig. 35, the picture *C* has four holes at the side, just as have the pictures *A*, *B*, *D*, *E*, etc., and when that film is passed through the film gate and intermittent mechanism, the "framing" will be preserved, because mechanically the film is the same in distribution of pictures and of sprocket holes as though no splice had been made. The difference is found in the "jump" of the pictures where a picture or more have been omitted, but the "frame" will not be disturbed as the splice passes.

In Fig. 36, the picture *C* has but three holes at the side. The result is that when the picture *B* is pulled out of the film window and the picture *C* is pulled in, the intermittent mechanism pulling down four holes will pull into the film window the three-quarter picture *C* and also the top quarter of the whole picture *D*. Again, upon the next operation of the shift mechanism, the intermittent feed pulls down four holes, the picture *C* will be pulled down, and there will be pulled into the film window the remaining three-quarters of *D* and the top quarter of *E*. This will continue, showing the lower three-quarters of one picture and the upper quarter of another, until the operator notices the screen and frames with his lever. This is called a splice "out of frame," because the splice throws the picture out of frame in passing.

Framing by Splicing. Every time a splice "out of frame" is passed, the operator must "frame" with his lever until he can find opportunity to stop in rewinding and cut the faulty splice. Then he may splice it correctly "in frame" and thus put his reel of film in frame at that place when running.

Titles. Titles should be given the same care as the picture scenes of the film. The main title, forming the head of the picture film, should be given the favor of a very long leader if the title itself has been shortened, so that there will be ample leader to thread through to the take-up reel, to turn a few pictures to test the working of the take-up before closing the take-up magazine door, and further to turn a few pictures and get the motion head under speed before opening the fire shutter. Thus, the audience will get the full benefit of whatever title there is.

Leaders and Tails. The purpose of the leader and tail is to give the audience the benefit of all of the picture which lies between. The leader is a piece of blank film or a piece of scrap film, just so it has good sprocket holes, cemented to the title end of the reel, and of sufficient length to thread through the motion head and test the mechanism before bringing the title into the film window. The tail is a similar piece cemented to the end of the picture. Its purpose is to enable the operator to run the full picture on the screen before closing the fire shutter, then to stop his motion head before the tail has run into the take-up magazine where it cannot be reached conveniently for rewinding. Some motion heads are so constructed for rewinding that if sufficient lengths of leader and tail are provided neither end of the film need be detached from either reel if but one reel is to be run repeatedly in the projector. Stopping the motion head before the tail has been drawn from the spring clip of the feed reel, the film is rewound and the rewinding stopped before the leader is drawn from the spring clip of the take-up reel; the motion head then is threaded and the film is ready to repeat.

Blank *black* film may be bought from the film exchange for leaders and tails if the reels come too short for the operator's convenience.

Dry Film. The gelatine of the motion picture strip is charged with glycerine by the manufacturer in order to keep it elastic and to make the film pliable in handling and projecting. As the glycerine and the water which is held in the gelatine gradually dries out, owing to winding and rewinding through the air and the heat of the arc lamp, the film strip becomes dry and brittle, with a tendency to crack the gelatine film, which then tends to scale off from the celluloid.

Films may be moistened and their pliability restored by leaving them unrolled over a little water, not permitting the water to touch the film. Take a bucket holding four or six gallons, cut a false bottom of heavy wire mesh or perforated metal with legs or downturned edges to hold it 1 inch from the bottom of the bucket. Pour in $\frac{1}{4}$ inch of water, set the false bottom in, and run in a reel of film, letting it fold around as film does in a basket from the projecting machine. Cover the bucket for half an hour. When the film is reeled up it will be found much more pliable.

Warped Film. With the film in a close roll, the drying from the edges goes on more rapidly than from the central portions of the strip. This warps the film, making it take a curved section crosswise of the film when it should lie flat; and it takes the curve sometimes in the film window, putting the picture out of focus on the screen. Such a film may be treated with the vapor bath as described above, or it may be treated more simply by cutting two disks of thick felt the size of the end of the reel, dampening them, putting one on each side of the reel, wrapping it and letting it lie over night. Discretion must be used to avoid getting the felt or blotting paper too wet.

OPERATOR'S DUTIES

Before the Show Begins. The operator usually is held responsible for delivery to the theater of the film for projection. If in a city where the film exchange is visited, the operator makes the visit, returning the old reel and bringing the new to the theater. If in a town distant from the exchange, he is responsible for the packing and shipment of the old reel and the receipt of the new one and its delivery from the express office to the theater. Such deliveries may be daily, or only once a week.

Being thus the messenger to the film exchange to obtain the picture film, he is also made responsible for getting the song slides, and not only the slides but the sheet music for the singer which is supposed to accompany the song slides but sometimes does not except after a special effort to get it. If title posters are used, the operator is held responsible for their delivery also, as being something substantially a part of the film reel. Being thus in charge of the signs for the theater front, it is good if he can improvise signs with a brush and a sheet of paper when occasion requires, or when the title poster for a particular reel of film cannot be obtained as usual.

The operator is responsible for keeping up the necessary supply stock for the operating room—carbons, oil, and condensers for the lantern; film scrap and film cement for repairing films; cover glasses and binding strip for repairing slides. Whether he purchases the supplies himself or asks the manager to purchase them is immaterial. If the supplies run short, he will get the blame, hence the burden lies on him to buy or keep kicking.

Preparing for Projection. On going into his iron-bound cage to prepare for the projection of films and lantern slides for the afternoon or evening, the operator should turn the motion head at a good fast rate for the "feel" of the machinery; then clean the film gate, notice the gate and tension plate and sprocket teeth or intermittent pins for wear; then oil up ready for the run; clean the lamp, dusting out the carbon dust which collects in the bottom of the lamp house from the sparks thrown off from the arc; examine the lamp and connections to see whether any wires are burning weak from the heat of the arc, and whether any joints are loose; dust the table top, and lastly sweep off the lens surfaces with the camel's hair brush; inspect the carbon stock, and if insufficient for the day it may be necessary to omit the dissolving lantern or to set the rheostat to a lower notch to save carbon; inspect the new reel of film, if time is had, strengthening any weak spot found and framing up the reel by resplicing "in frame" any splices found "out of frame"; trim the lamp with carbons of sufficient length for the first reel, light up, center and focus the light, put in a slide to be sure that the stereo lens is still in focus; then put a piece of scratched mica (not celluloid) in the film gate for the test of the motion head lens for focus. He now is ready to begin projection.

Conducting the Program. The duties of the operator after the projection begins were discussed in an article which appeared in the *Nickelodeon* and which seems to cover the subject. It reveals the fact that the operator has duties other than turning the crank, and that training in actual service beyond the mere mastering of the mechanism of some particular projecting machine is an essential to the person who would become an efficient operator and valuable theater employe:

Every nickelodeon has its *stage manager,* whether it knows it or not.

There must be of necessity among the attendants of a motion picture theater some one who decides when the pictures shall start, when the song shall be sung, and how long the intermissions between the performances shall be. This person is the one who really is in charge of the program of the theater, and upon him depends to some extent both the pleasure of the patrons and the profits of the owner.

In a small theater, running to one reel of film only, without songs or specialties of any kind, the total manual duty connected with this duty of controlling the program is the turning off of the lights in the room when the pictures start, and turning them on again when the performance is finished. This requires merely a switch in the operator's booth, convenient to his hand, for the house lighting system.

In such an instance, the operator rewinds the reel of his film and adjusts the carbons of his lamp. He is ready to start the next performance. At this point, it is within his discretion to start the performance immediately, to delay it according to a time schedule, or to delay it as long as he thinks the audience will endure the wait without impatience. It can be seen plainly that the pleasure of the patrons and the profits of the owner lie within control of the person who is in charge of the program.

As the theater acquires additional features of entertainment the duties of controlling the program become more and more complex.

By adding an illustrated song, the operation of the projecting machine becomes more complex. In addition, the operator must have a push button to call the singer at the proper time to be in readiness when the song slides come upon the screen. If an automatic piano or phonograph is running as a *barker* in front of the theater and is making so much noise as to interfere with the enjoyment of the song (it may be noted that patrons sitting in the rear of the room will be much nearer to the automatic *barker* than to the singer), then the automatic barker must be stopped during the song, requiring another switch to be controlled by the operator.

If ventilating fans are running in the theater during the pictures, these in all probability must be stopped during the song, since the whirring of the fans, not at all objectionable during the pictures, would be decidedly so during the song. With an illustrated song an accompanist is required; this usually dispenses with the expense of an automatic piano, the accompanist playing during the intermissions. The operator in control of the program therefore is required to call the accompanist as the program nears the close, that the intermission music may start promptly at the close of the pictures.

What, then, are the total duties in such a theater which are required of the operator usually thought of as only a picture-machine operator?

Take the easiest form of song-and-picture program, in which the pictures follow the song.

In the intermission, the pianist is on duty. The operator, having his picture film in readiness, (1) lights his arc and (2) rings for the singer. He then (3) turns out the lights of the auditorium, (4) turns off the ventilating fans, (5) turns off the automatic barker and (6) projects the song slides in proper order and at the proper instant for each. At the conclusion of the song, he (7) shifts to the motion head and begins to turn the crank of the kinetoscope, and at the same time, with his free hand, (8) he turns on the ventilating fans and (9) turns on the automatic barker. This is the time for the accompanist's period of rest, and as the operator nears the end of the reel he (10) rings for the accompanist to be in readiness for the intermission. At the end of the motion pictures he (11) projects the *Please Remain* slide; then (12) turns on the auditorium lights, (13) cuts off the current from his arc light, (14) rewinds the film and (15) adjusts the carbons of his arc lamp. Last, but by no means least, the operator (16) decides the length of the intermission before repeating his routine of sixteen separate duties.

With every added feature of entertainment, the operator's duties become more complex.

An alternative plan of managing the performance consists of placing a *stage manager* at the theater entrance, inside the auditorium, and providing him there with all necessary control facilities. An array of electrical switches control the *barker,* the house lights and the ventilating fans; push buttons are arranged to ring buzzers or bells in the operator's booth and in the waiting room of the performers in the rear of the picture screen. An answering buzzer circuit may run from the waiting rooms to the stage manager's station, or even a telephone line may be installed. In the picture machine operator's booth there is merely one switch controlling the current for his arc lamp and one button which rings a buzzer at the stage manager's station.

This system operates as follows:

When the machine operator is in readiness, having rewound his films and adjusted his lamp, he signals to the stage manager by pushing his button; then he merely awaits the command to go ahead with the projection.

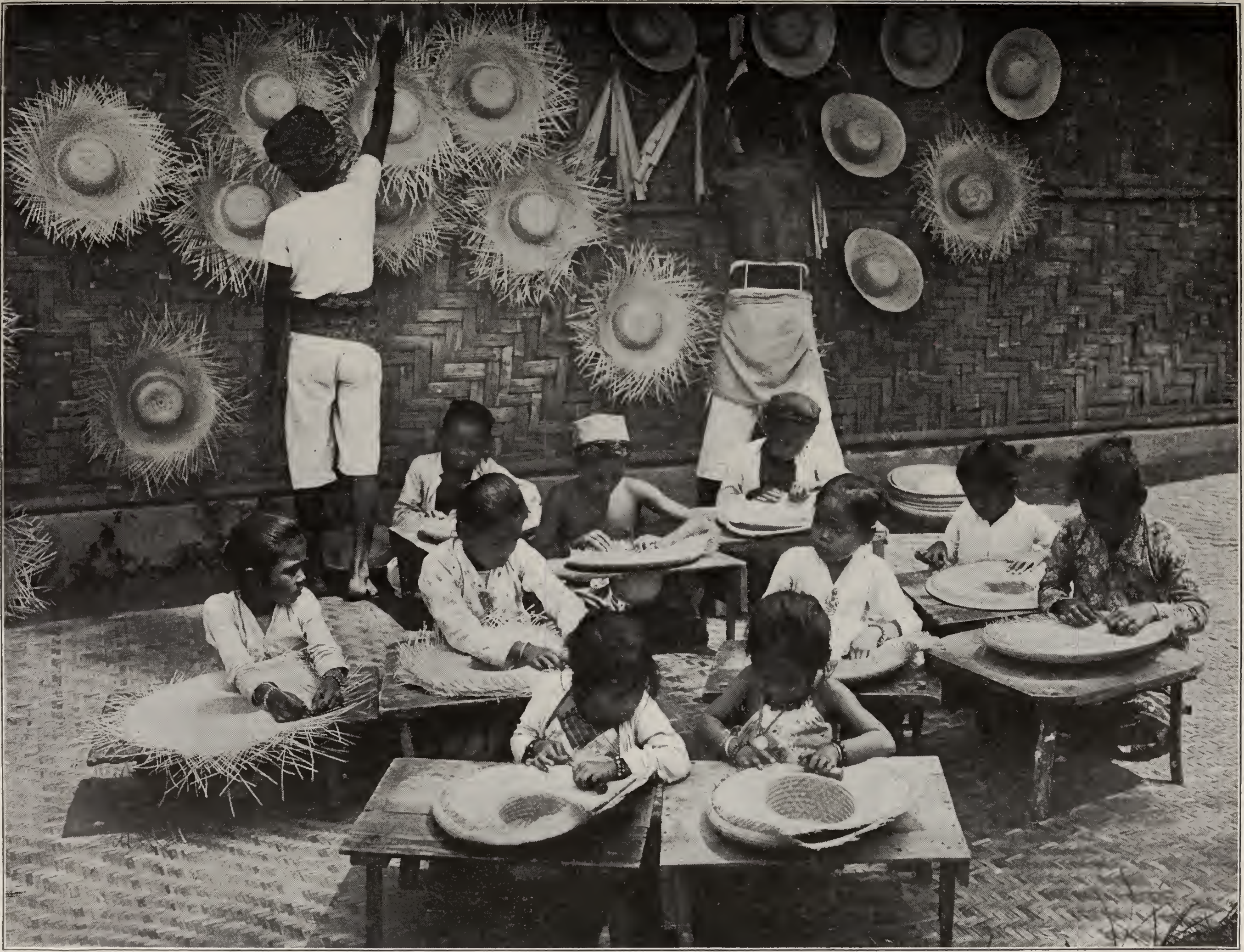
When, in the judgment of the stage manager, the performance shall begin, he rings for the singer and signals the operator (two buzzes for the song slides) and when the first slide flashes upon the screen the stage manager cuts off the house lights and stops the *barker* and the fans. With applause after the song, the stage manager uses his discretion as to whether an encore shall be sung, and either rings again for the singer and signals to the operator (three buzzes to put the chorus slide back on the screen) or rings one buzz to the picture machine operator to go ahead with the motion picture film without encore; at the same time, the stage manager starts the fans and the *barker.* As the pictures near the close, the stage manager rings for the pianist and then turns on the house lights as the picture closes. He then must wait for the buzz from the operator indicating that the projecting department is in readiness again.

When vaudeville or specialties of any kind are added to the performance, the duties of the stage manager become more complex, and the machine operator, whose post is a responsible one, should be relieved of them.

Keeping Up With the Times. The live projection operator who desires not only to give a good show and hold his present job but also to fit himself for a better one, must keep posted upon the new ideas that are being developed in the art of projecting and theater operating, and the new devices which are being produced constantly by enterprising manufacturers. Subscribe for some motion picture magazine, and read not only the feature articles of the magazine, which attract attention first because of their illustrations, but read the editorials and the advertisements. Read particularly, and with care, the department usually entitled "Manufacturer's Department" or "Notes of the Trade," a department which is a fusion of advertisement and editorial and which supplements both the advertising and editorial columns, illustrating and commenting upon almost every new thing which is produced in the motion picture business.

Buy the new books of the art as they are brought out by the publishers; read them and understand them as far as possible. Talk with everybody you meet in the picture business and add to your own knowledge whatever they know. Participate in the "Questions" columns of the motion picture magazine to which you subscribe, either with questions on the business or with contributions from your experience. Be alive, whether on or off duty. Then when some good, live manager needs a good, live operator and searches his memory he will remember YOU.

SCENE FROM PHOTOPLAY, "THE ROSE OF OLD ST. AUGUSTINE," OR "A TALE OF JEAN LAFITTE, THE PRIVATEER".
Courtesy of *Selig Polyscope Co., Inc., Chicago*



SCENE FROM "MAKING BAMBOO HATS IN JAVA," BY ECLIPSE
Showing Some of the Educational Possibilities of Motography
Courtesy of the *Kleine Optical Co., Chicago*

SCENE FROM PHOTOPLAY, "THE MINOR CHORD"
Courtesy of *Independent Moving Pictures Co., New York*

MOTION HEAD

PART II

SPECIFIC PROJECTING MACHINES

Introduction. The progress of the art prevents the presentation, in any one book, of instructions for operating all and every one of the projection machines used or offered for sale. A new detail is added to some standard machine every month, and perhaps an entirely new model is brought out by an old and well-established manufacturer, or a new manufacturer springs into the arena to fight for a part of the motion-picture trade with a projecting machine entirely new and entirely different in many or all of its mechanical details. To keep up with such development requires at least a monthly review of the new devices and improvements; this is afforded you by the trade magazines.

To understand the current news of improvements and to be able by reason of that understanding to operate any of the new devices with their peculiarities and special conveniences, the operator should master one machine thoroughly and learn to operate it perfectly so far as its particular mechanical details go. Then, or before then, he must master the theory of each operating part and regard the part of the projector which effects each function as being a little integral device in itself which may be replaced with an improved device designed to effect the same function, the improved device being built into the projector without changing any of the other details of the machine.

When an operator has attained a skill with any one machine that will enable him to operate it "with his eyes shut and one hand tied," and when he has added to this physical skill, the mental mastery of the separate results to be accomplished by the projector, and has learned how each mechanical detail of his projector is specific to one of these separate results, then it is a matter of minutes, not hours, before he becomes equally skilled with any machine with

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which he is confronted and is able to recognize its defects, its eccentricities, its bad adjustments, and its worn parts, and to adjust and replace them and give a good show with improved projection.

In some projectors, the feed reel magazine is square, in others it is round; the operator who has skill in placing a full reel of film in a square magazine cannot fail to have the skill to place it in a round one, nor will he forget to close and latch the door, nor forget to feed the end of the film down through the film outlet before closing and latching the door. In every other detail will skill in the operating of one machine lead to the operating of another.

A film outlet must hold a film close while passing through; it must have a release device to open the outlet if too close to push the end of the film through easily. The Edison outlet has but one pair of rollers, through which the end of the film is pushed easily. The Power's Cameragraph has a long film outlet with a pair of rollers at the lower end where the film cannot be pushed through easily, but one of the lower rollers, spring-pressed, is hung with its axle through slots and the ends of the axle project so as to be caught by the fingers, whereby the spring roller may be drawn back to open the outlet and let the end of the film freely through. The Edengraph and Motiograph use a four-roller trap so built that the rollers at one end are opposite a slot, and the end of the film may be carried into the rollers through the slot of the outlet.

Such small differences in mechanical detail will be all that is to be found in changing from one projector to another. Every projector has its feed reel, its feed reel magazine, its feed magazine film outlet, its upper steady feed, its upper feed loop, its film gate, its intermittent mechanism, its take-up. Every lamp has its four adjustments, as has been discussed and classified heretofore, and so on through the entire list of necessary functional apparatus units. Learn one, learn it well, and watch for the differences when taking charge of a strange machine.

In ordering repair parts for any projecting machine, give as much information to identify the machine as it is possible to give. To write to the Nicholas Power Company asking for a complete new intermittent mechanism seems hardly sufficient information. It may be assumed by the company when receiving the order that the mechanism is desired for a Power's Cameragraph, but the intermittent mechanism for the No. 5. Cameragraph is a Geneva, while the intermittent for the No. 6 Cameragraph is a pin-cross movement—and which one do you need? Some manufacturers change details or dimensions of parts without changing the number of the machine; for that reason, give the serial number if it can be found.

The serial number of the motion head is a number stamped upon the frame somewhere with numbering punches, just as a similar number is placed upon watches, bicycles, and pianos, for identification.

Write in this manner: "Please send me for Motiograph, 1910 model, serial number 1263, a framing device connector bar 167 and a crank handle 13½." The numbers of the parts are taken from the illustrated lists of repairs, if possible to identify them in the printed lists; if not, then the best description possible must be given, or if convenient to do so the worn or broken part may be sent for identification and duplication. Any lack of care in ordering is liable to produce an error in shipment, or to produce a delay by causing the dealer to write, asking for further information in order to enable him to fill the order.

In the following pages, complete instructions are given for a few leading machines, not only for operating them after they are set up, but for setting them up for beginning service. The later paragraphs will not repeat instructions where they are similar to those already given.

THE EDISON KINETOSCOPE

Installation. First, place the narrow side of the case up; remove the top cover; and check packing slip.

Remove packages in main compartment as follows: adjustable legs, rewind, condensers and lenses, cone and bracket, switch, cover and cords, lower magazines, lamp house with arc lamp, crank and lever inside, upper magazine, long baseboard. The small compartment contains the mechanism. The rheostat, completing the outfit, is shipped in a separate box.

Assembling. Place long baseboard, Figs. 37 and 38, on floor, bottom side up, and loosen thumb screws on flanges. Extend leg rods in all tubes and insert in flanges, fastening by means of leg clamp screws, adjusting to proper height by clamp screws provided.

INDEX OF PARTS

1 Carrying case
2 Base board
3 Base board wing nuts
4 Objective lens on front of cabinet
5 Lamp house
6 Lamp house casting
7-8 Lamp house casting guides
9 Bolt and wing nut
10 Rear slide rod
11 Rear slide rod set screw
12 Front slide rod
13 Front slide rod set screw
14 Condensing lens holder
15 Condensing lens hood
16 Mica lid
17 Slide carrier frame
18 Condensing lens thumb bolt
19 Lamp house door
20 Ruby window in lamp house door
21 Rear door of lamp house
22 Hand wheel for backward and forward adjustment of lamp
23 Hand wheel for lowering and raising lamp
24 Carbon feed lever
25 Lamp body lower binding post
26 Switch binding posts
27 Lamp body upper binding post
28 To rheostat binding posts
29 Switch binding posts for the main circuit wires
30 Film aperture
31 Stereopticon support rod
32 Upper reel
33 Top idler
34 Top sprocket
35 Upper spring idler
36 Film gate
37 Upper gate idler
38 Film gate tension springs
39 Lower spring idler
40 Lower sprocket
41 Crank
42 Framing device lever

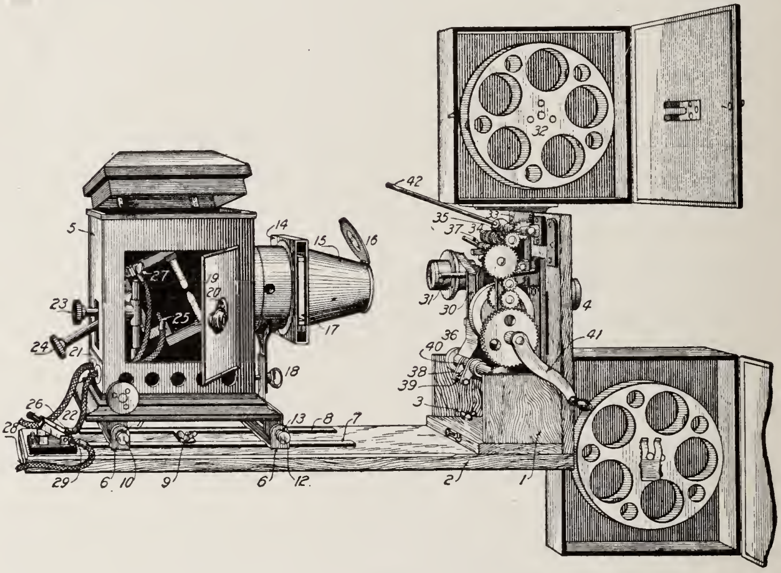


Fig. 37. Edison Exhibition Kinetoscope

INDEX OF PARTS

1 Mica lid
2 Condensing lens hood
3 Slide carrier frame
4 Condensing lens holder
5 Ruby window in lamp house door
6 Lamp house door
7 Lamp house lid
8 Hand wheel for lowering and raising lamp
9 Carbon feed lever

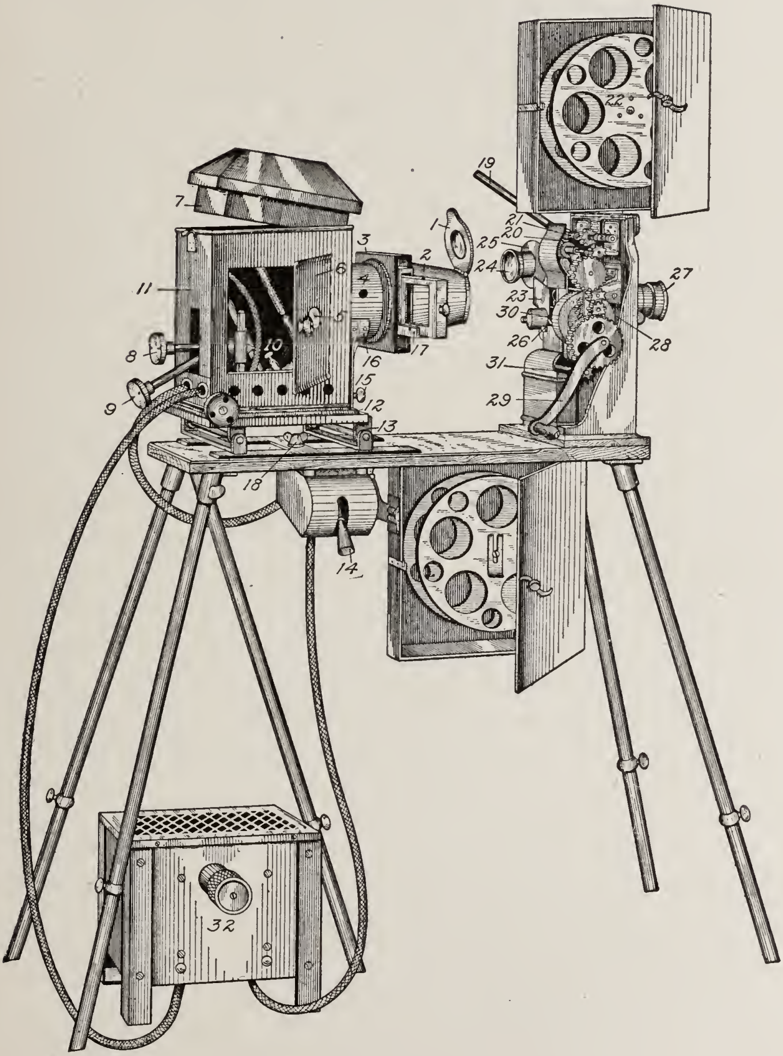


Fig. 38. Edison Kinetoscope, Underwriters' Model Type "B"

10 Lamp body lower binding post
11 Lamp house
12 Lamp house baseboard
13 Lamp house baseboard guides
14 Switch
15 Condensing lens thumb bolt
16 Cone holder casting
17 Slide carrier
18 Baseboard clamp casting thumb bolt
19 Framing device lever
20 Top sprocket
21 Top idler
22 Upper reel
23 Film gate
24 Stereopticon objective lens
25 Stereopticon ring casting
26 Film aperture
27 Position of objective lens on front of mechanism
28 Take-up attachment binding screws
29 Crank
30 Lower sprocket
31 Lower spring idler
32 Rheostat

Carefully unpack mechanism and remove mechanism cover by loosening thumb screws. Place mechanism on baseboard, securing it with wing nuts screwed in baseboard.

Assemble lower magazine with take-up by removing wing nut on take-up base and clamping long arm over shoulder screws on take-up bracket and base. Tighten center thumb screw directly under mechanism, then place long bolt over take-up sprocket shaft pulley passing it through slot in baseboard, then around small pulley next to magazine, over large pulley on take-up reel shaft, and under second small pulley. Adjust upper magazine and bracket to mechanism support by means of the thumb screws already displaced when mechanism was uncovered.

One film reel will be found in each magazine.

The winding crank, adjusting lever, and stereopticon attachment which will be found inside of lamp house, may now be attached to the mechanism in their respective places.

Adjust the stereopticon to the left side of the mechanism support by the thumb screw, washer, and wing nut provided.

The stereopticon lens and lens holder, which are already assembled, may now be placed on the stereopticon slide rod. Screw motion picture lens into position on front of mechanism support through the lens ring and flange already attached to support.

Lamp House. Loosen the two small set screws over the round opening provided for slide rods in lamp house bracket. Place the lamp house and lamp house baseboard on this bracket with that side of the lamp house containing a large round opening, toward the mechanism. Insert the two slide rods through round openings in bracket, and through slide castings, being sure that the flanged ends of rods are on the stereopticon side of the lamp house. Tighten the two set screws in lamp house bracket above referred to, to hold the rods in position. These rods must not project beyond the edge of the casting where they are fastened with the set screws. Place the rear slide or door of lamp house in position.

Cone and Bracket. Place the condensers in cone, and set the same in position, in front of lamp house, fitting it in the round opening of lamp house, and passing the cone bracket over the thumb screws which will be found in the casting attached to the front of the lamp house baseboard, then tighten the thumb screw. When placing condensing lenses in cone, be sure that the side of the condenser with threaded ring will be in position next to the arc lamp. Place slide carrier in cone, where provided.

Arc Lamp. This will be found packed inside the lamp house; remove, clean interior of lamp house, set the arc lamp in lamp base by placing the stud at bottom of lamp post in the socket in center of lamp base, then tignten round head screw, so that the lamp may not be jarred out of position, when operating. Attach ends of asbestos-covered connecting wires by removing the binding post thumb screws on upper and lower carbon holder bases. The short connecting cord should be attached to the lower carbon holder, and the long connecting cord to the upper carbon holder.

Operation. *Carbons.* For *direct current,* the upper carbon should always be the positive pole, while the lower should be the negative pole, and the latter set $\frac{1}{8}$ inch in advance of the former so that a crater will form in a position toward the condensers. With carbons of the same diameter, the positive burns twice as rapidly as the negative, thereby requiring more or less adjusting downward to keep the crater in the optical axis, for this reason some operators prefer a $\frac{5}{8}$-inch soft cored upper, or positive, carbon and a $\frac{1}{2}$-inch hard carbon in the lower, or negative, carbon holder.

This difference in cross-section compensates in the matter of lineal consumption, and the crater is kept in its proper place with less difficulty. The carbons, when burning, should be kept at all times as near to 3/16 inch apart as possible. Most satisfactory results are obtained from D. C. when using from 20 to 25 amperes.

Where *alternating current* is used, the carbons should be set in alignment, although some operators claim to get better results by placing the lower carbon slightly in advance of the upper. This, however, is a matter of choice, and the careful operator will usually experiment in the adjustment of the lower carbon until he gets it in a position most satisfactory to himself.

Both carbons should be soft cored, and kept as nearly as possible to $\frac{1}{8}$ inch apart. They are consumed at about the same rate, the upper carbon about 8 per cent more rapidly than the lower, owing to the upper tendency of the flame.

The most satisfactory results are obtained on alternating current using from 35 to 50 amperes.

Focusing. Adjust the lamp house by means of sliding base on bracket to a distance of 16 inches between lamp house and aperture or picture gate; open film gate on mechanism, and proceed to regulate lamp by using adjusting handle below lamp house hinged door. Slide either backward or forward until you have obtained a white spot $1\frac{3}{4}$ inches in diameter covering the opening in the picture gate. For vertical adjustment, use upright adjusting handle on the arc lamp post. Adjust the projecting lens so as to have a sharp outline of opening in picture gate on the screen.

Stereopticon Lens. Slide the lamp house on the slide rods to the flanged ends. Adjust stereopticon lens in front of the condensed rays, sliding either backward or forward on stereopticon slide rods, until the proper focus is obtained. Adjusting the stereopticon lens in this manner permits of sliding the lamp house from side to side, alternating between motion picture objective lens, and stereopticon lens as desired, without rearranging either arc lamp position or lamp house position.

Connecting Cords. The free end of the short cord to be attached to a contact on that side of the switch where no open poles are placed. The free end of the long connecting cord attached to the upper carbon holder to be fastened to one binding post in rheostat or transformer. The second long attaching cord to be placed on the second contact of switch where no pole is placed, with the other end attached to the second binding post in rheostat or transformer.

Take=up Device. The take-up device comes detached from the head piece mechanism, and is adjusted as follows: Insert the left-hand part of the take-up device, Fig. 39, through the hole in the lower part of the cabinet. The hooks *3* on the frame casting of the take-up device hang on the half-inch stud in the lower part of the head piece mechanism. The lugs *4* are fastened into position with two 8-32 machine screws. When the film has been threaded, as described, and fastened to the spring clip of the core of the take-up reel, and the crank handle is turned, the film will be wound on the reel as fast as it comes through the machine. If the reel does not revolve fast enough, the friction adjusting nut *5* should be screwed in, thus causing the friction wheel *6* to engage friction disk *7*, causing the reel to revolve faster and take up all the slack. The lever *8* is used to disengage the friction wheel from the friction disk and is only used when the film is rewound from the take-up reel to the top reel. When the film is rewinding, this lever should be thrown back toward the reel. At all other times the handle of the lever should point outward. When the film is rewinding, use the friction spring *9*, to check its momentum if it turns too fast. This is accomplished by pressing down the spring until the end rubs against the inside of the crown gear *10.* This spring is only used when the film is rewinding. At all other times it should stand in position as indicated on Fig. 39.

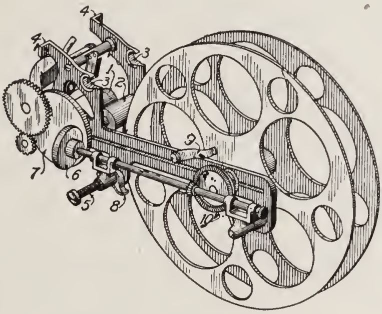


Fig. 39. Take-Up Device

INDEX OF PARTS

1	Lower sprocket	6	Take-up friction wheel
2	Lower idler pulley	7	Take-up friction disk
3	Take-up frame hooks	8	Disengaging lever
4	Take-up frame lugs	9	Momentum friction spring
5	Take-up friction adjusting nut	10	Crown gear

Wiring. The binding post *10,* Fig. 40, on the lamp connects by short wire with switch binding post, and the lamp binding post *11* connects by long wire with rheostat binding post.

The interior of the lamp house is planned for all lights known to exhibitors, including the electric arc light, for both alternating and direct current, the oxy-hydrogen (or calcium) burner, the Edison gaso-oxygen burner, or the methyl-etho saturator. Assuming now that we are assembling the electric burner, observe the following rules, and refer to Fig. 40. The lamp base *1* is assembled in the lamp house. Place lamp post *3* in socket *4* and tighten with binding screw. Next place carbon in carbon holders *14* and tighten carbons with thumb screws *9*. The lamp being now in the lamp house, is ready to receive the wires *12*.

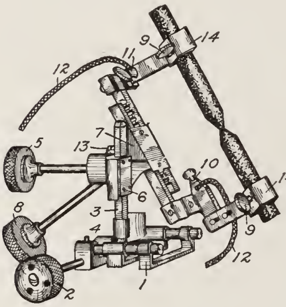


Fig. 40. Calcium or Gaso-Oxygen Light

The main line should be wired for 110 volts direct current, or 52 or 104 volts alternating current, 25 to 40 amperes, using a standard 30-ampere cut-out, or combination switch and fuse block with 40-ampere fuses. If alternating current, 60-ampere fuse may be used.

When the wires *12* are connected, the carbons are brought together by raising the feed lever *8* to make the arc. After closing the circuit through the carbons, they should be separated about $\frac{1}{4}$ inch to make a perfect arc. This is done by lowering the feed lever slightly. A perfect circle of white light should cover the aperture *30*, Figs. 37 or 38. All this is done before the film is threaded into the mechanism. Should the circle of light on the aperture be imperfect, it may be remedied by either or all of the following adjustments:

INDEX OF PARTS

1 Arc lamp base
2 Hand wheel for forward and backward adjustment
3 Lamp post
4 Lamp post base socket
5 Hand wheel for lowering and raising
6 Lamp post friction screw
7 Lamp body
8 Carbon feed lever
9 Carbon holder thumb screws
10 Lamp body lower binding post
11 Lamp body upper binding post
12 Wires
13 Raising and lowering lever friction screw
14 Carbon holders
A. Socket for alternating current
D. Socket for direct current

By swinging the lamp either to the left or right (revolving on the lamp pcst), using the hand wheel *5*, Fig. 40, as a lever; or by raising or lowering the lamp by turning hand wheel *5*, or by a forward and back adjustment by hand wheel *2*. The size of the circle light covering the aperture can be increased or diminished by sliding the lamp backward or forward.

If a "ghost," or dark spot, appears in the middle of the screen, this can be remedied by sliding the entire lamp house backward or forward on the large baseboard.

The set screw and tension device *6* is placed on the lamp for the purpose of giving an amount of friction necessary to prevent the lamp from dropping on the post from its own weight. This set screw should be snugly tight, but not tight enough to bind. The set screw *13* is for tightening the friction bushing on shaft of handle *5*. This also prevents the lamp from dropping from its own weight. This, however, should not be too tight.

Six Edison Rules. *First.* Adjust the height by raising or lowering the lamp on the lamp post *3* by the hand wheel *5*, Fig. 40, until the points of the carbons, when brought together, are opposite the center of the condensing lens.

Second. Turn on the current by closing knife switch. Lift up mica lid *16*, Fig. 37. The revolving mica shutter behind the framing plate should be turned so as to leave the space between the framing plate and the objective lens entirely clear. This should be done before the film is placed in the machine.

Third. The lamp should then be adjusted by moving backward or forward until a bright, clear, round light just covers the square hole in the framing plate. If the circle of light is too large, light is lost and the brightness of the picture is impaired. When properly adjusted, the light on the screen will be bright and free from color.

Fourth. The operator should adjust the objective lens by turning the focusing screw, until the square on the screen is sharply defined. Only a slight adjustment is then required to sharpen the picture when projected.

Fifth. All this should be done *before* the film is threaded up.

Sixth. Never turn the light on the film until it is in motion, and if by accident or mistake the film should stop while the light is on, shut mica lid *16*, Fig. 37, at once, or the film will catch fire.

Calcium or Gaso=Oxygen Light. When calcium or gaso-oxygen light is used by the operator, the arc lamp base *1*, Fig. 40, remains in position on the floor of the lamp house. Into the socket *4* is inserted the eccentric holder post, with which every complete projecting kinetoscope is equipped. The post must not be clamped too tightly; it must be loose enough to permit the eccentric holder to move to right or left and forward or back, as may be necessary in centering the light on the condenser. The clamp screw may be tightened after the center is found.

Directions for Operating. Remove jet from lantern to place lime pencil in straight position into lime cup within $\frac{1}{4}$ inch from point of jet.

Turn on the hydrogen gas (black cylinder) first until the flame becomes the size of a light from an ordinary gas burner. Then turn the oxygen gas (red cylinder) slowly until the light gets bright and dazzling. Too much oxygen dulls the light and may extinguish it; yellowish flames of hydrogen should always be noticed around the lime pencil. If not intense enough, add small portions of the gases until the light is nearly hissing. Turn off oxygen first and then hydrogen.

Turn lime pencil about every few minutes, to prevent cracking of condensers and see that no draft strikes the lantern.

If light snaps out, shut off both gases and re-light as above stated.

Observe rules 3, 4, 5, and 6 above.

The gaso-oxygen saturator and burner are especially adapted for traveling exhibition purposes, and also for home use. A complete description of the gaso-oxygen outfit, together with directions for generating the gas and adjusting the burner, will be found under the heading "Directions for Operating the Gaso-Oxygen Light." Rules 3, 4, 5 and 6, above, must be carefully observed.

Threading up the Film. The film is wound on the upper reel *32*, Fig. 37, by placing the end in the spring clip on the core of the reel. The emulsion side, that is, the gelatine side, should be in. When the reel is full, the end of the film is brought under the lower front side of the reel. It passes over top idler *33*, under top sprocket *34*, over the upper spring idler *35*. Now open film gate *36*.

Engage the film on the intermittent or middle sprocket (not shown in cut), leaving about 3½ inches of the film slack. The gate is then closed and secured by latch, thus forcing the slack film into a loop, the lower part of which passes behind the upper gate idler *37*, as shown. The film is now between the framing plate and the film gate *36*. As it passes the aperture *30* the film is held against the framing plate by the springs *38*. This checks the momentum of the film and prevents the center of film from touching the gate, thus avoiding possibility of scratching.

A second loop is then formed. This is known as the lower loop and should be about 2 inches in length. This is formed by passing the film under the lower take-up sprocket and over the grooved idler spring pulley, which is closed against the film to hold it firmly against the lower sprocket. Having then formed both loops, and the picture sitting squarely between the tension springs *38* and grooved framing plate, the film is next passed over the hard rubber roller, which will be found immediately in front of the lower take-up sprocket. The end of film is then passed under the core of the take-up reel and secured by the steel clip on the core. The machine is then ready to be set in motion, which is done by turning the crank *41* away from the operator. The framing lever *42* should be adjusted with set screws bearing on the flat surfaces of the lever. The picture is then framed upon the screen by lowering or raising the lever.

The emulsion side of the film should be always toward the light and the picture should show in the aperture upside down.

Framing Device. As has been noted there is no setting or adjusting of the film as it passes over the frame plate. This is rendered unnecessary by the framing device. After the picture appears on the screen, if it is not framed exactly, it is very easily accomplished by raising or lowering the lever *42* until the proper effect is obtained.

Adjustable Rheostat. After the rheostat is placed in circuit as described under the heading "Wiring," the current may be regulated by raising or lowering the contact spring. Before turning on light, the contact spring should be set at the bottom of the rheostat so as to prevent too much current being drawn suddenly, and burning out fuses. If, after lighting the lamp, the light is not strong enough, raise the contact spring until the desired strength is obtained.

General Instructions. The intermittent sprocket shaft is provided with bronze eccentric bushings, and set screws are placed in the cast frame to hold these bushings secure. The idea of making the bushings eccentric is to permit the operator to adjust them so that the star wheel and cam fit perfectly, thus avoiding unsteady pictures. If you wish to show steady pictures upon the screen at all times, it is necessary to look carefully to the adjustment of these eccentric bushings, and when these eccentric bushings, or the star wheel or cam, or the intermittent sprocket become worn, it is highly essential to good results that they be replaced at once. See that all set screws are kept tight, and the machine well oiled, so that it will run smoothly and regularly at all times. Be careful not to use too much oil, as surplus oil is liable to spatter on the film and damage it.

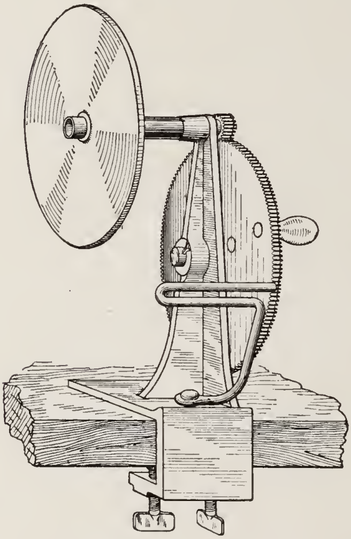


Fig. 41. Film Winder

Films should be handled carefully and kept clean and free from dust.

They should be wound on reels when not in use, and placed in a dust-proof reel box, and if possible kept in a cool, dry place.

The films should be kept in perfect condition, any broken places being mended at once.

Film Winder. This ingenious little apparatus, **Fig.** 41, is a great labor-saver. It is small and compact and can be placed on any table or shelf that may be near the projecting machine, being provided with thumb screws for instantly adjusting it to a table. If a Kinetoscope is not equipped with a take-up reel, this film winder is an absolute necessity.

After the film has been run through the projecting machine the end is placed in the groove of the winding shaft with the emulsion side *in;* and by turning the crank of the winder slowly, a 100-foot film can be properly wound in less than ten seconds of time. There is an attachment on the winder for removing the film from the shaft after it has been wound, in perfect safety and in a perfect roll.

This attachment consists of a nickel-plated disk of about the diameter of a 150-foot film when rolled up. This disk slides from

THE MEXICAN PROSPECTOR RESCUES GEORGE MAXWELL IN THE NICK OF TIME
Scene from Photoplay, "The Lucky Card"
Courtesy of *Essanay Film Mfg. Co., Chicago*

front to back of the shaft. After the film is wound, the exhibitor slides the disk from back to front carrying the roll of film with it, thus freeing it from the shaft.

Edison Film Mender. First open all gates. Place one end of the film on left-hand side of repairer, emulsion side up, with the bottom line of picture as near the center of the glass as possible, then close and clamp left-hand gate over the film. Place the widest part of the gauge, which forms part of the repairing outfit, against the closed gate, and, holding it firmly on the film, take a sharp knife and cut off that portion of the film which projects beyond the gauge.

Next, reverse the gauge, place it with the narrowest part over the film and close against the locked gate, moistening that portion of the film which projects beyond the gauge, and scrape off the emulsion. For this use a moderately sharp knife. Be careful not to scratch away the celluloid. After this is done, open the gate and move back the film so that it will be entirely covered by the gate, and re-lock the gate.

Next take the other end of the film, place it on the right-hand end of the repairer in the same manner as was done before, with the picture line as near the center of the glass as possible. Use the gauge in the same manner as before, that is, use the widest side and cut off that portion of the film which projects. This end of the film should not be moistened, nor should the emulsion be scraped away.

After this is done, release the left-hand gate and place that end of the film in the same position as it was after the first operation had been performed. You will then note that the ends will overlap about $\frac{1}{8}$ of an inch. Moisten both ends of the film with the film cement where they overlap, cement the two ends together carefully and smoothly (the one with the emulsion scraped off underneath), close down the center door or gate and lock same securely. Leave the film in this position for from 20 to 30 seconds, when same will be thoroughly cemented together.

When about to take the film from the repairer, open the center gate first and if the film is found to adhere to same, by working same carefully to the right and left the film will be released from the gate without breaking the joint.

Operating Gaso=Oxygen Light. The gaso-oxygen light is the result of a series of exhaustive experiments, and it is offered frequently as a substitute for the methyl-etho light outfit, for the reason that it is strong, simple, and cheap to operate. The operation of the light is very simple, and in order to make it perfectly clear, the directions are given under three different headings, as follows: (1) the chemicals; (2) the oxygen generator; (3) the gaso-oxygen saturator and burner.

Necessary Chemicals. The necessary chemicals can be obtained in almost any large town if the original supply becomes exhausted. Buy the chemicals from a reliable druggist, and see that there are no chips or other combustibles mixed with the chlorate of potash or the black manganese. The following chemicals will suffice for two hours continuous running: 2 lbs. chlorate of potash, and $\frac{1}{2}$ lb. black manganese (in the retort *1*, Fig. 42), $1\frac{1}{4}$ pints 90 deg. gasoline (in the saturator), and 1 lime pencil.

Mix 4 parts of chlorate of potash and 1 part of black manganese thoroughly and distribute it equally along the entire length of the retort *1*. Turn the retort so that the seam comes on top.

FOR GENERATING OXYGEN GAS INTO GAS BAG ONLY

1 1 Russia iron retort and cleaner $3\frac{1}{2} \times 18$
2 1 Retort stand
3 1 Burner (gas or spirit)
4 16-inch lined tubing from retort to purifier
5 2 Purifiers, complete with rubber stoppers, glass and metal tubes
6 6-ft. rubber tubing $\frac{3}{8} \times$ 3-16 connecting purifiers to gas bag
7 1 55-gal. gas bag, stopcocks and regulator
8 5-ft. rubber tubing $\frac{1}{4} \times \frac{1}{8}$ from gas bag to light

FOR GENERATING AND COMPRESSING OXYGEN GAS

1 1 Russia iron retort and cleaner, $3\frac{1}{2} \times 18$
2 1 Retort stand
3 1 Burner (gas or spirit)
4 16-inch lined tubing from retort to purifier
5 2 Purifiers complete, with rubber stoppers, glass and metal tubes
6 6-ft. rubber tubing $\frac{3}{8} \times$ 3-16 connecting purifiers and gas bag
7 1 55-gal. gas bag and double stopcock.
8 5-ft. rubber tubing $\frac{3}{8} \times$ 3-16 from gas bag to pump.
9 1 Compressor
10 5-ft. lined tubing and couplings from compressor to cylinder
11 1 gauge attachment, regulator and 5-ft. tubing to light
12 1 25-ft. cylinder and key

Fill the retort *1* as above. Connect the purifiers *5* as shown in Fig. 42. The purifiers should be half filled with pure water and $\frac{1}{4}$ ounce of caustic soda placed in bottle nearest the retort. Be careful that the ends of tubes *AA* are *below* the surface of the water and the ends of tubes *BB, above* the water.

The gas bag *7* should be rolled before connecting, to eject all air. Place the burner *3* on retort stand *2* at one end of the retort *1.* Gas will generate as soon as heat is applied. Allow a little oxygen to be given off, before finally connecting the retort *1* with the tubing *4* to the first purifier *5.* To ascertain when the gas is pure, light a piece of brown paper, *then blow it out,* and hold the *smoldering* portion in front of the arm of the retort *1.* When the gas is pure, the paper will burst into flame; then connect with tube *4* and see that all the tubes are straight. Now open the tap of the gas bag *7.* Scores of people forget to do this. The gas bag *7* is now filling with pure oxygen gas. Move the burner *3* along under the retort *1* inch by inch until the chemicals are exhausted. As soon as the bag is quite full, turn off the tap at gas bag, remove the burner from the retort, and disconnect the tubing.

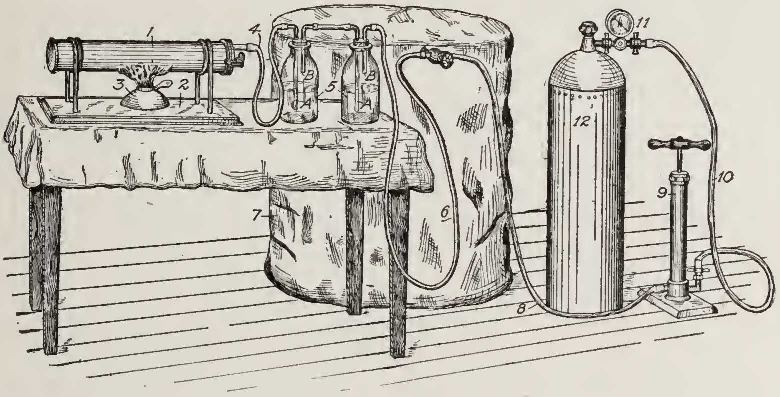


Fig. 42. Oxygen Generator

When using the gas bag a pressure of 150 to 200 pounds is required to procure the best results, which is obtained by means of press boards and weights. The capacity of the gas bag is 55 gallons, and about 2 pounds of chemicals must be used to fill it completely.

The gas bag should be kept in a warm place when not in use.

Wash out the retort with hot water as soon as possible, and do not attempt to pick out the baked residue with a chisel or other sharp instrument, as this spoils the retort. Don't leave mixture to harden; unless the retort is cleaned at once, it is almost impossible to remove the hardened residue.

When the high-pressure method is used, the oxygen gas is compressed into cylinder *12* with the compressor *9* until about 100 pounds pressure is reached in cylinder *12*.

Gaso=Oxygen Saturator and Burner. The gauge attachment, Fig. 43, is supplied with two needle valves; turn on first the one leading to the saturator, see that valves *C* and *D* are also open, and light the jet, then turn on the oxygen from valve *B*, and regulate your light in the same manner as oxy-hydrogen gas is used, until the light is bright and dazzling. Too much oxygen dulls the light, and may extinguish it. Little red flames should always be noticed around the light, to show that sufficient gasoline or ether is supplied. If the light is not intense enough, add small portions of the gases until the light is nearly hissing.

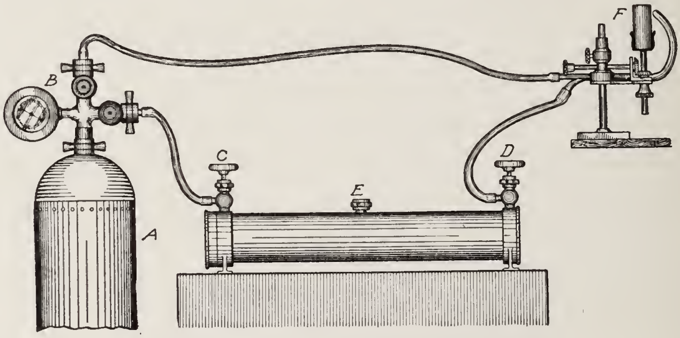


Fig. 43. Gaso-Oxygen Saturator and Burner

Always turn on the gasoline first when lighting, and when through, turn off the oxygen first. Have the lime pencil properly adjusted about ¾ inch above the point of the jet when starting, and turn the pencil upward about every five minutes, to prevent the flame from burning through the pencil and striking back against the condenser, as this will crack it. See that no draft strikes the lantern, thereby causing the condenser to break.

Should the light snap out, it is a sign that too much oxygen is used, then both gases must be turned off, and relighted as above directed.

It is imperative that 90-degree gasoline only is used, as lower grades will not evaporate quickly enough to give sufficient supply of lighting material.

In changing the fluid from gasoline to ether, it is necessary to open the saturator, take out the cotton, and have it thoroughly cleaned, by exposing it to the air until it is perfectly dry.

Note the following differences over the other saturators:

Ninety-degree Gasoline or Sulphuric Ether can be used with utmost and absolute safety, as there is no direct connection between fluid and flame and consequently no danger. Any number of lights can be run from one saturator, and any single or dissolving lantern jet, or dissolving key can be adapted.

The 1,000 candle-power jets give the same light with gasoline saturator, as with oxy-hydrogen gases.

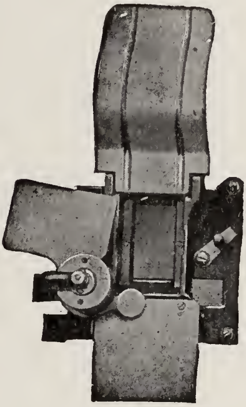


Fig. 44. Automatic Shutter for Underwriters' Model of Edison Kinetoscope

The saturator is equipped with needle valves and regulators, guaranteed air tight.

If no cylinder is used, and the oxygen gas is supplied direct from the gas bag, it is necessary to use a stand with two-way connections near the saturator to regulate the gases conveniently, in the same manner as above described.

Automatic Shutter. *On Underwriters' Model.* Under no possible conditions can the light be thrown upon the film except when the film is in motion. When the shutter, Fig. 44, is wide open it automatically locks so that no power is required to keep it open, eliminating undue wear on the gearing and causing easier operation of mechanism. When the speed of the machine falls below a certain point, however, it automatically unlocks and closes.

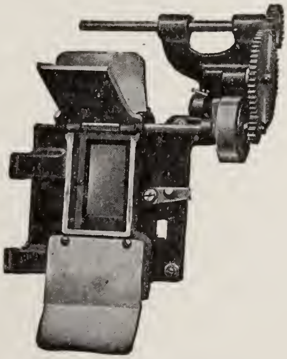


Fig. 45. Automatic Shutter for Exhibition Model of Edison Kinetoscope

On Exhibition Model. This very simple but effective device automatically shuts off the light when the film is at rest, and absolutely prevents the light being thrown upon the film except when the latter is in full motion.

This shutter, Fig. 45, consists essentially of two parts: a film gate, upon which is mounted a metallic shutter and centrifugal governor, and a casting upon which is mounted an intermediate gearing, through which the shutter is connected to and operated by the large driving gear.

The exhibition automatic shutter is not regularly furnished with the improved exhibition model machine, but is attached, at an extra charge, when ordering a machine.

Rheostats. The question of rheostats is one about which there has been much discussion and diversity of opinion, due principally to a lack of knowledge of real conditions. It is not practical to make what might be termed a "universal rheostat" or one equally well adapted to meet all conditions. A rheostat with a capacity of 25 to 40 amperes on *direct-current* circuits of 100–125 volts will give perfectly satisfactory results under ordinary conditions in the hands of an intelligent operator. To get equally satisfactory results with *alternating current,* 35 to 60 amperes are required with the same line voltage. For direct-current circuits of 100–125 volts, the Underwriters' Model (coil type) rheostat is recommended, and the Underwriters' Model (type "B") for alternating-current circuits, on account of its greater capacity. The latter will give equally satisfactory results on both direct- and alternating-current circuits of 100-125 volts, *but on direct-current circuits care should be taken to adjust it so that not more than 25 to 40 amperes are consumed in the line.*

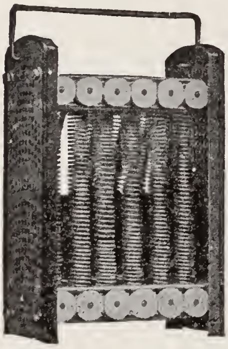


Fig. 46 Coil Type Rheostat

The coil type rheostat, Fig. 46, is regularly furnished with the exhibition model projecting Kinetoscope, while the new grid type, Fig. 47, is supplied with the Underwriters' Model machine.

In the design and construction of the grid type rheostat the old-style wire resistance coils have been discarded and replaced with *cast metal grids,* supported and insulated by water and fireproof material.

The rheostat can be used on either direct or alternating current of any frequency, with equally good results, and in either case a maximum current can be obtained *without excessive heating* on a line voltage varying from 100 to 125 volts.

The front, back, and sides are enclosed with solid sheet metal, while the top and bottom are enclosed with perforated sheet metal.

The operating switch, switch contacts, and binding posts are all inside the sheet metal frame and are thoroughly protected from outside contact. The switch handle is outside the sheet metal case and a pointer indicates the position of the switch.

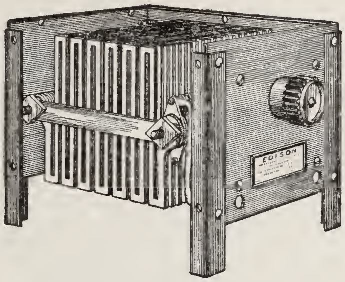


Fig. 47. Grid Type Rheostat

TABLE I

Projection with Edison Lenses

No. 1	M. P. Lens	Project a picture 3 ft. wide for every 10 feet of distance.
No. 4	“ “	
No. 1A	Stereo. Lens	
No. 1AA	“ “	
No. 2	M. P. Lens	Project a picture 3 ft. wide for every 13 feet of distance.
No. 5	“ “	
No. 2A	Stereo Lens	
No. 3	M. P. Lens	Project a picture 3 ft. wide for every 19 feet of distance.
No. 6	“ “	
No. 3A	Stereo. Lens	

THE MOTIOGRAPH

How to Install or Set Up the Motiograph. The complete machine and equipment Fig. 48, comes packed in a single case. Take out all the parts and see that all are wiped free from dust and that none are left in the packing case or overlooked in the packing material.

The mechanism base, lamp house, sliding frame, backward and forward slide rods and brackets are screwed to the baseboard. The arc lamp, saddle, post, etc., will be found inside the lamp house.

When the pedestal base is used to support the Motiograph it should be fastened very firmly to the floor with $\frac{3}{8}$-inch lag screws, large square head wood screws, of good size, and care should be taken to see that as nearly as possible contact with the floor is had on all sides. In order to do this, as a rule, it is advisable to use wedges of hard wood. It will be well to screw the base tightly to the floor and then drive the wedges just tight enough at different points so the base will rest with equal pressure on all sides.

To assemble the equipment set the lamp house in position on the lamp house slide frame, and insert the two cross slide rods through the ears on both the lamp-house base and the sliding frame, screw-end first, and screw them into the ears in the sliding frame that comes next to the operator, which is the right side when looking from the rear toward the front of the instrument. Set the Motiograph mechanism on the circular swivel base *2* and screw down the swivel thumb wheel. (Cut above shows the 1908 and 1909 Models with

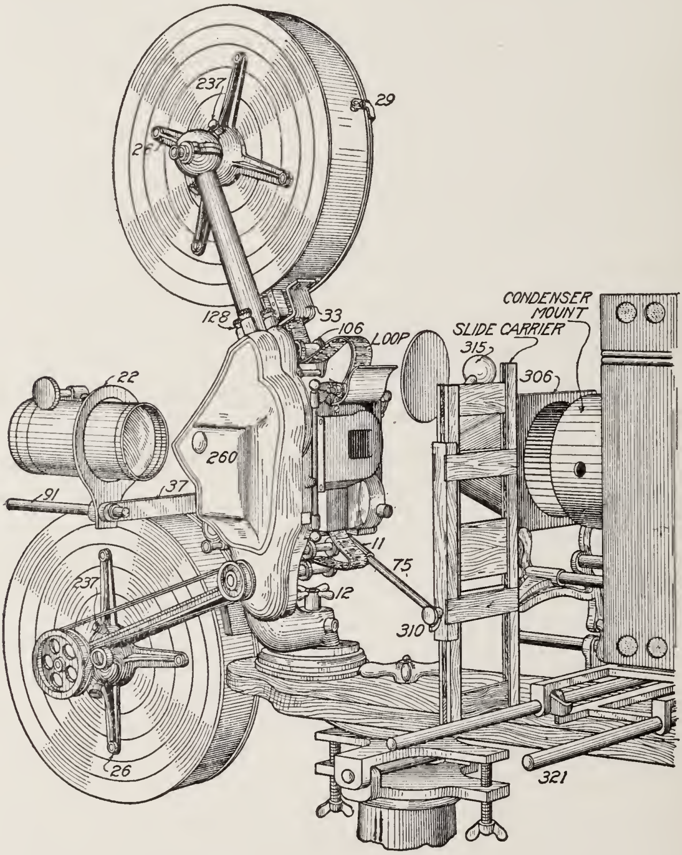


Fig. 48. Details of Motiograph

thumb wheel *12* on top of the base. The thumb wheel for the 1910 Model is larger and is under the base.) Attach the upper reel arm *7A* by entering the shaft and cross pin into the rewind vertical socket arbor, and screw into place with the three reel arm thumb screws *128*. Attach the take-up or lower reel arm *9A*, Fig. 49, with the three reel-arm thumb screws *237*. Place the take-up belt in position on the take-up pulleys with the idler pulley under the belt, first having loosened the tension screw of the belt idler *109* until the belt is quite loose.

Remove the objective lens from the little pasteboard box and screw it into position on the front plate of the mechanism, first having removed with a soft cotton handkerchief any dust that may have accumulated on either the front or rear surface of the lens. Be sure that the extension collar is in place, if the lens is of such focus that it requires one. Otherwise the lens can be brought to the focal point. Place the framing lever handle *75* in the framing lever socket *11*, and screw it into place. Loosen the little thumb screw on the crank *13A*, place the crank in position on the crank arbor and tighten the little thumb screw on the crank so it engages with the groove in the crank arbor to hold the crank in place. Remove the stereopticon lens bracket screw and attach the stereopticon lens bracket *37*. Attach the stereopticon lens ring to slide rod on stereopticon lens bracket, tightening into place with the thumb screw. Remove the stereopticon lens from its box, carefully wipe from the surface of the lens any dust that may have accumulated, remove the flange ring from the lens. Insert it back of the lens ring with the bead or rim to the front; insert the lens and screw it in place. It is unnecessary to have the flange ring attached to the cast ring or to have the cast ring threaded.

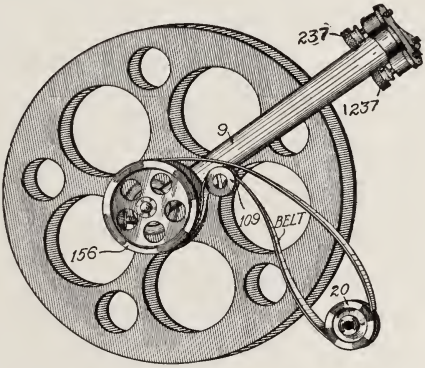


Fig. 49. Take-Up Device

The location of the stereopticon objective lens on the rod support should be such that the distance from about the center of the lens (from front to back) and the front surface of the front condensing lens is equal to the focal length of the lens. For example, a stereopticon lens of 12½-inch focus should be located so that the distance from the middle of the stereopticon objective lens to the front of the condensing lens is about 12 inches when the rack adjustment of the lens is so set that it will allow of liberal adjustment in either direction. The stereopticon lens bracket rod may be screwed into either the front or the rear of the bracket depending on the focal length of the lens.

The universal reel clamp is used for the 1908 and 1909 Models No. 1 and No. 2 machines It will be found clamped on the reel arbor. This should be removed by holding the clamp with one thumb and finger and loosening the thumb screw with the other. This will loosen the clamp and it may be slipped off the arbor. Now put the reels in place on the arbor, and turn around until the key pin on the arbor enters the seat (hole or keyway) in the reel. Slip on the universal clamp with the projecting pin next to the reel, insert the pin into the keyway or slot in the core block of the reel, and tighten the clamp thumb nut, which will hold the reel securely on the arbor. The universal reel clamp has been dispensed with for the Model No. 1A for 1910 and a new arrangement called a *jointed reel shaft latch* is used.

When fireproof magazines are to be used, they should be attached before the reels are put in place. To attach the fireproof magazines unscrew the two thumb screws in the magazine spiders, *26*, so as to let their points pass the flange on the reel arm, put the magazine in place on the reel arm by inserting the boss on the reel arm into the opening of the spider. Have the fire trap or valve toward the upper or lower feeding sprocket (depending on which of the reel arms you are assembling), tighten the thumb screws to engage the flange on the reel arm. Now, open the magazine and attach the reel in the same manner as in instructions previously given. The magazines are marked on the inside "upper" or "lower."

The condensing lenses are mounted in a nickel-plated mount and are held in by the use of two inside telescopic bands. The condenser mount is held in position on the front of the lamp house by two clamps and two screws. The mount may be removed from the lamp house front, for changing or cleaning the lenses, by turning the two clamps until the flattened sides of the clamps come next to the flange of the condenser mount. The mount is usually left attached to the lamp house for shipment. The flat side of the condensers should always be outward and the convex sides toward each other. The surfaces of the condensing lenses should be free from dust, perspiration, or other accumulations to insure the unobstructed passage of the light.

The No. 1A 1910 framing device, Fig. 50, can be used in the 1909 No. 1 or No. 2 mechanisms by buying the short connecting link *107A* to connect the framing handle with the framing device, and the 1909 framing device, Fig. 51, may be used in the 1910 machine by using the 1909 link *167*. Both framing devices are practically alike with the exception of the vertical casting, which can be interchanged between the two, and the change can be made from one to the other by removing the four screws in the side.

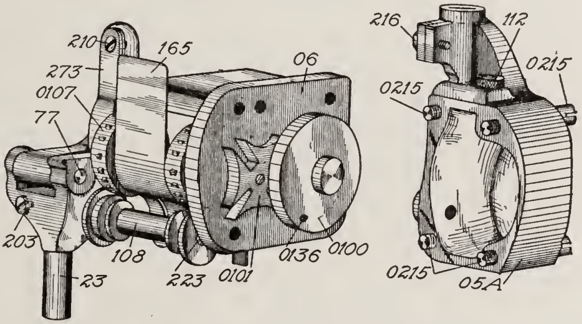


Fig. 50. Motiograph 1A 1910 Model Framing Device

Attach the stereopticon slide carrier to the lamp-house slide carrier swing *310,* and clamp in position with the thumb screw on top of the carrier swing. If the lamp house cone *377* has been removed for convenience in packing for transit, it is to be attached by inserting the two dowel pins in lamp-house support *306* and will be held in place by the two small thumb screws on the side of the cone support.

Test the slide on the lamp house and see that it slides freely on the backward and forward and the sidewise movements.

The proper adjustment for the lamp house on the backward and forward slide should be a point where the distance between the front face of the condensing lenses and the film on mechanism will be about 12½ inches when operating at a distance of about 60 feet from the screen with a picture of moderate size. When operating a greater distance from the screen, the distance between the condensing lenses and the aperture plate should be greater, depending on the length of focus of the condensing and objective lenses that are being used and the individual preference of the operator. Some operators prefer a greater distance between condensers and film, even when operating at the above distance from the screen.

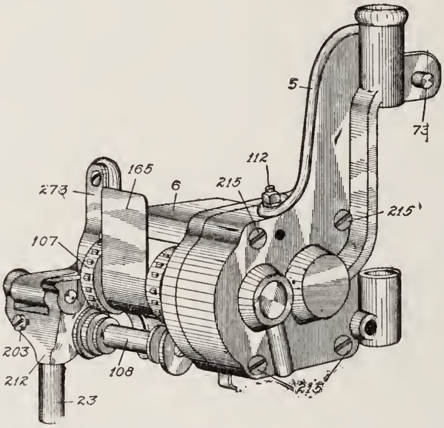


Fig. 51. Motiograph No. 2, 1908 and 1909 Framing Device

Motiograph Lens Adjustment. The lens should give a sharp focus on the screen, giving clear detail. If the lens does not give a sharp focus after turning the focusing ring to both extremes of adjustment, it will be an indication that the extension collar used is either too long or not long enough, in which case test may be made by unscrewing the lens from the collar and holding it by the hand, shifting to different distances from the film to determine what position is necessary to give a sharp focus. The use of mica with scratches on it for the test focusing is recommended.

Open the film gate, swing it to the left, turn the crank of the motion-picture machine so the leaves of the shutter do not cover the opening in the aperture plate, so as to allow a free passage for the light through the aperture plate and the objective lens. This should be done before the film is placed in the machine.

The objective lens on the front of the motion-picture machine should now be focused by turning the focusing ring until the square of light on the screen is sharply defined: that is, the margin of the light opening should be clean and sharp and not fuzzy. When this is done only a slight adjustment is required to focus the picture sharply when the film is in place. All of the above adjustments should be accomplished before the film is placed on the machine. Some operators use a piece of mica on which some sharp scratches have been made with a knife, for the purpose of getting a sharp focus before the film is put in place. A piece of ruled mica is furnished with each Motiograph.

When using the Motiograph equipped with the automatic fire shutter, it will be necessary to open the film gate when doing the preliminary focusing of the objective lens, and to see that the illumination on the screen shows a clear outline of the margin of the aperture plate.

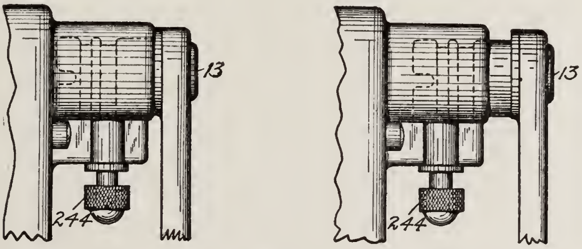


Fig. 52.

Position of Crank of Motiograph When Showing Pictures

Position of Crank of Motiograph When Rewinding Films

Threading the Film. When film is received from the manufacturers wound in a roll, the center of which is too small to admit the core block of the reel, it is necessary to rewind it. This may be done by removing the lower reel from the arbor, place the roll of film on the bare arbor, insert the outer end of the film under the spring clip on the core block of the upper reel, and wind the film on the upper reel.

To shift the connection between the crank and the reel arbor when using the Model No. 1 for 1909 or No. 1A for 1910, all that is necessary is to press a spring plunger at the right of the crank boss of the main frame, Fig. 52, turn the crank slightly, pull it toward you about $\frac{3}{16}$ of an inch, and the spring bolt will automatically drop into the other groove and hold the crank in place for rewinding the film, Fig. 53.

After the film has been wound on the upper reel, remove the upper reel and place it on the take-up below. Place another reel on the upper reel arm, take the outer end of the film (which was on the inside of the roll when received), pass it to the rear of the upper reel, inserting the end under the spring clip, and again wind the film on the top reel, making sure that the emulsion or dull side of the film is wound toward the outside.

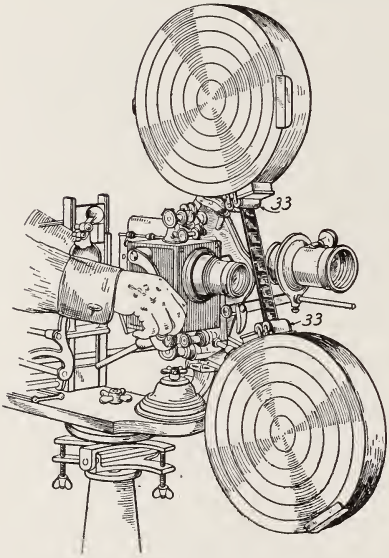


Fig. 53. Motiograph Rewinding

When the film has been wound back on the upper reel, press the spring plunger and return the crank to its normal position. When using this form of reeling mechanism in combination with fireproof film magazines, it is unnecessary to remove either the magazines or the reels for rewinding; in fact, with reasonable care and by the use of a few feet of white undeveloped film on each end of the picture film as leaders, the operator will see that the film is nearing the end, and it can be run and rewound time after time and it will not be necessary to disconnect the film from either reel until the film is to be changed for a different subject.

Draw from the reel a length of about 2 feet of film, press the handle of the upper sprocket roller bracket *24* to the left as far as it will go, pass the film under the sprocket wheel, so that the teeth of the wheel engage in the perforations of the film, and press the top of the roller bracket to the right until the roller comes into place against the sprocket wheel and holds the film in place. The roller brackets should not press tightly against the film, and there should be just room enough between the roller and the sprocket wheel for the film to pass without being pressed. The adjustment of these rollers is accomplished with the screw *203* and check nut. This adjustment is always properly set before the machines leave the factory, and should not require any further attention until the rollers have become somewhat worn, unless some one tampers with the machine. However, it is well to keep this adjustment in mind.

Press the film gate latch *154* to open the gate, swing the gate back, raise the intermittent sprocket roller bracket *23* until it stands in a horizontal position, lay the film on the aperture plate in such a position as to leave a loop at the top, as indicated by the word "loop," and return the intermittent roller bracket to its original position, to hold the film in place on the sprocket teeth of the intermittent sprocket.

The intermittent roller bracket has a screw adjustment the same as those of the upper and lower roller brackets, except that it has a check screw instead of a check nut to hold the adjustment.

Press downward on the handle of the lower roller bracket, pass the film over the lower feeding sprocket wheel, leaving a loop between the intermittent and the feeding sprocket as indicated by the word "loop" in Fig. 48. See that the teeth engage the sprocket holes in the film and turn the roller bracket to place. Pass the loose end of the film over the core block of the lower take-up reel and under the end of the spring clip.

When threading the film, place the framing lever about the middle of the two extremes of its up and down movement, for by so doing the upper and lower loops may be properly proportioned so as not to require rearrangement.

Turn the handle of the machine over to the right toward the front of the machine at the rate of about one revolution per second. The exact speed at which the handle should be turned will readily be determined by the movements of the figures in the pictures, which should be normal and natural, and by the flicker, which must not be too great.

While the machine is in motion test both bottom and top loop to see that they are sufficiently long. Take hold of the framing lever handle *75*, swing it up and down (while the machine is in motion only) as far as it will go, and when at the two extreme positions there should still be a small loop remaining. If the loop is entirely taken up, the roller bracket should be opened and the loop extended sufficiently. If this is not done the film may be torn. You are now ready to start. The loops should not be too long as they have a tendency to vibrate considerably, which may make the pictures unsteady.

It is important when running new film to scrape off the spots of film emulsion that collect on the film tension springs and the ribs of the aperture plate. These accumulations, if allowed to remain, have a tendency to not only scratch the film, but make it run unsteady, and are liable to be the cause of slightly tearing the corners of the sprocket holes in the film, besides making the machine run heavy, with increased wear to the parts. A silver dime is a good instrument to use for scraping them. On the first run film, the tension springs should be scraped before starting to make each run of a thousand feet. Do not scrape the springs with a knife or other steel instrument, as it would be liable to leave a rough surface on the tension parts that would injure the film.

Instructions. *To remove the front of the Motiograph* loosen the two thumb screws at the bottom, lift up the spring at the top while pulling the front plate forward sufficiently to disengage the spring, and lift it up to disengage it from the thumb screws below.

Adjustments. There are four important adjustments in the Motiograph that it will be necessary for the operator to concern himself with.

(1) The adjustment of the idler on the take-up belt should be just tight enough to make sure that the film will be wound up on the reel as fast as it comes through the machine. If too tight it will pull too hard on the film, with the result that it is liable to tear the sprocket holes. The flexible broad flat belt, in combination with the adjustable idler, furnishes a most sensitive, yet positive, means of taking up the film without doing injury to it. When the idler is adjusted, the check nut on the screw should always be tightened so as to retain the adjustment. If the belt is too tight when the tension is off, stretch it by pressing the two sides together near the large pulley.

(2) The adjustment of the sprocket rollers or idlers should be given careful attention. There should be just room enough for the film to pass freely between the roller and the sprocket without pressure on the film. The film rollers are adjusted to position by a set screw that passes through the roller bracket. After the screw is

THE BULLY GETS INTO TROUBLE
Scene from Photoplay, "On the Desert's Edge"
Courtesy of *Essanay Film Mfg. Co., Chicago*

properly adjusted the check nut or check screw, as the case may be, should be tightened so as to retain the adjustment.

(3) The Geneva movement that operates the intermittent film sprocket wheel, called the *star and cam,* will need to be adjusted only after it is worn to such an extent that the intermittent sprocket wheel can be slightly turned when at rest; that is, when the pin in the Geneva driver or pin wheel is on the opposite side of the pin wheel from the star wheel. The adjustment is accomplished by the two set screws that clamp the eccentric bushing in position. To set the Geneva parts closer together, loosen the lower set screw very slightly and tighten the upper screw. Have the adjustment of the Geneva driver, cam, or pin wheel just close enough to the star wheel that the movement of the pin wheel shaft will be free and easy, yet so there will be no circular movement to the intermittent sprocket wheel while it is at rest. Do not tighten so the cam or pin wheel will not work perfectly freely.

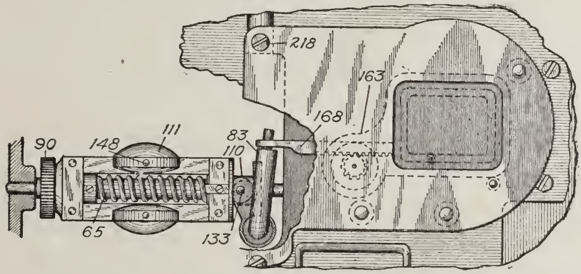


Fig. 54. Motiograph Safety Shutter

The governor that operates the fireproof shutter may be removed from the Motiograph if necessary by removing the bushings at each end of the governor shaft or arbor, or by removing the gear bridge and the inside bushing. The bushings are held in place by set screws.

(4) The adjustment of the governor and fireproof shutter, Fig. 54, is accomplished by sliding endwise the pivot bushings in the frame. To adjust, loosen the screws that hold both bushings, hold the two between the thumb and finger and slide them slightly out and in when the machine is running at regular speed, until the point is reached where the fireproof shutter will be raised clear up, and at the same time, the little bar which connects the shutter with the governor crank bar will rest loosely on the governor crank pivot.

In no instance should it be drawn tight. Now tighten the screw on the inside bushing, then loosen the outside bushing just enough so the governor will work freely, and tighten the screw on that bushing.

Don't adjust the governor too tight; if too tight, the machine will run hard and, besides, the wear will be excessive.

Oiling. It is absolutely necessary that a motion-picture machine be kept well oiled, in order to keep it in good condition, and that it may do good work. Remember that while in operation the balance wheel shaft and Geneva action, which operates the intermittent sprocket, is making nearly 1,200 revolutions per minute, or 72,000 revolutions per hour, and that when giving fifteen shows per day, of twenty minutes each, the balance wheel and Geneva action has made 360,000 revolutions. No machine can be expected to endure such work without proper care. Be sure that *all* of the bearings are oiled and that none have been overlooked.

When running afternoon and evening all of the bearings should be oiled twice during the day, besides which the Geneva movement and governor shaft pivots should be oiled after every other show, or make sure that there is a sufficient amount of oil in the Geneva movement casing, that the Geneva movement is kept constantly lubricated.

It is important that the oiling should be carefully done, and that none of the bearings should be overlooked. It is advisable to establish a practice of always oiling the bearings in the same order, as in this way you will be less liable to overlook any of them. Care should be exercised not to have any oil on the sprocket wheels and on the film pressure rollers, as oil in these places would be transmitted to the film and badly damage it. All surplus oil remaining on the outside of the oil holes, or in other places where it might come in contact with the film, should be carefully removed with a soft cotton cloth.

The quality of oil used on a motion-picture machine is of great importance. Do not get the impression that anything sold under the name of oil is good enough. Never oil with kerosene or any oil that is highly adulterated with kerosene, as it has practically no lubricating properties. Do not use ordinary lard oil that is adapted to use on heavy machinery; it is too coarse and will gum the bearings.

There are oils on the market, some of which are extensively advertised and are recommended for lubricating, polishing furniture, and as rust preventives, etc., that are not at all suitable for the lubrication of a motion-picture machine. Sewing-machine oil of fine grade is most desirable, and the best place to get it is at a sewing-machine agency. A cheap grade of sewing-machine oil should not be used owing to its poor quality as a lubricant.

Vaseline is used in the framing device oil chamber. Remove that part of the framing device which forms the cover to the oil chamber by removing the four screws in the side. Take the remaining part of the framing device in one hand, and with the flexible metal tube of white vaseline in the other, force the vaseline into the opening of the flange of the pin wheel, where the pin is located until that opening is well filled, then force the vaseline all around the outside of the flange of the pin wheel. Then cover the entire surface of the star with a liberal coating. This is all that will be required. Care must be taken not to put in too much vaseline, as the rapid rotation of the star and cam wheel will have a tendency to force it out through the oil cup, which would be very undesirable.

After replacing the cover put eight or ten drops of fine lubricating oil in the oil cup on top of the framing device, which will mix with the vaseline and soften it to the proper consistency. If care has been taken in applying the vaseline thoroughly the machine should run, even under the heaviest usage, for at least three weeks without further attention to this part, except to add occasionally a few drops of fresh oil. At the end of that period, if the vaseline has become blackened, it is time to remove it, clean the pin and star wheel, wash them off with benzine or gasoline and put in fresh vaseline as described above.

Vaseline is used as a lubricant for the star and pin wheel and is without an equal for the Motiograph. It is necessary, however, to avoid the cheap qualities put up in bulk, and never, under any circumstances, use carbolated vaseline. Use the white vaseline put up in flexible metal tubes, which may be had at drug stores or it may be ordered of the manufacturers of the Motiograph.

When oil only is used without vaseline it is preferable to use a very heavy oil of fine quality, rather than a thin oil.

To keep a machine in good condition it should occasionally have the working parts cleaned with gasoline to remove dirt, gum, and old oil, the parts wiped dry with a soft cotton cloth, and fresh oil applied.

The high-speed spindles of the Motiograph all run in interchangeable phosphor-bronze bearings. These may be replaced with new ones when worn. Phosphor-bronze is one of the best anti-friction metals known, and with proper care none of the bearings should need replacing for a long time.

The fire-trap rollers should be kept clean. In case the film should become ignited and the flame extend to the fire trap or valve, some of the melted celluloid is liable to stick to the rollers and when dry it becomes very hard and brittle and would do much damage to the film if allowed to remain. In a case of this kind the rollers should be carefully cleaned. The rollers should also be cleaned from time to time to keep them free from accumulations of dust, oil, etc., which will do more or less injury to the film. Alcohol or refined benzine is good for the purpose.

The belt idler adjustment screw is provided with two check nuts, the purpose of which is that when the desired adjustment has been secured, one nut may be locked against the other, in order that the screw together with the nuts locked in position on the screw, may be loosened while the film is being rewound, as otherwise the pull would be too heavy on the film if the tension was allowed to remain the same as when the film is being taken up on the rewind. After rewinding, the adjustment screw may be instantly returned to its former position.

If, for any reason, it should become necessary to remove the gear bridge of the 1908 or 1909 models, the disconnecting of the gears would throw the shutter out of time until the shutters are reset—that is, the wings of the shutter would not cut off the light at the proper moment with relation to the movement of the film, the result of which would be to show a ghost, especially on the announcements. This would not occur with the 1910 No. 1A model. The shutter might also be thrown out of time from coming in contact with something inserted within the frame while the shutter is in motion.

Setting the Motiograph Shutters. *Setting the Intermittent Double No. 1 Cone Shutters on the No. 1A Motiograph, Model 1910,* Fig. 55. The instructions for setting the double shutters of the No. 1A Motiograph for 1910 are different from the instructions for the shutters of the No. 1 Models, 1908 and 1909. The reason for the difference is that in the 1908 and 1909 Models the movement of the shutters is in the opposite direction to those of the 1910 Model.

The principle of setting the shutters for the Motiograph is the same as for any other moving-picture machine, that is, the larger wings of the shutters should cover the light opening or aperture during the time that the intermittent sprocket and film are in motion, and the smaller wings should pass during the exposure while the film is at rest, Figs. 56 and 57.

To set the shutters, remove the front plate, which carries the lens, after which remove the outer shutter wing (the one nearest you), loosen the screws on the inner shutter, leaving the shutter just loose enough to be turned easily by hand, and tight enough so it will not move of its own accord. Remove the gear cover, after which take hold of the balance wheel and turn the mechanism in the same direction as during the operation of the machine; turn very slowly until the intermittent sprocket wheel starts to move, after which set the upper edge of the large wing of the inner shutter about 1/16 inch below the center of the aperture plate when looking on a line parallel through

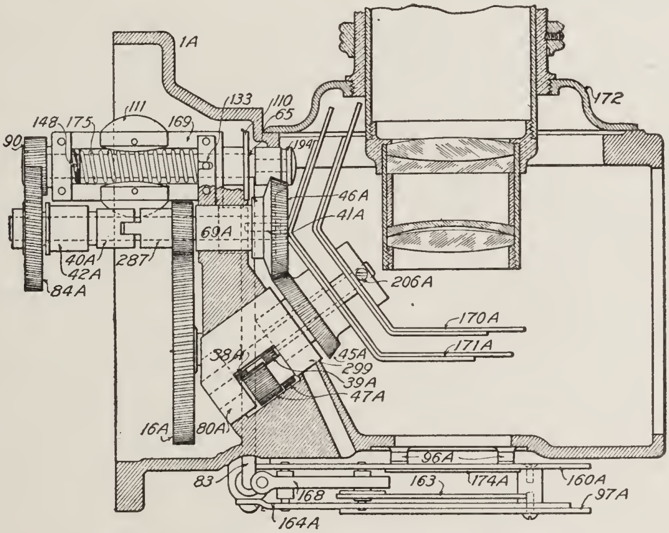


Fig. 55. Sectional View of the Intermittent Shutter Arrangement of the Model No. 1A, 1910 Motiograph

the center of the light aperture. These measurements refer to the 36-degree shutters. Now revolve the mechanism slowly in the same direction, observing when the intermittent sprocket wheel stops that the lower edge of the large wing of the inner shutter is about 1/16 inch above the center of the aperture plate.

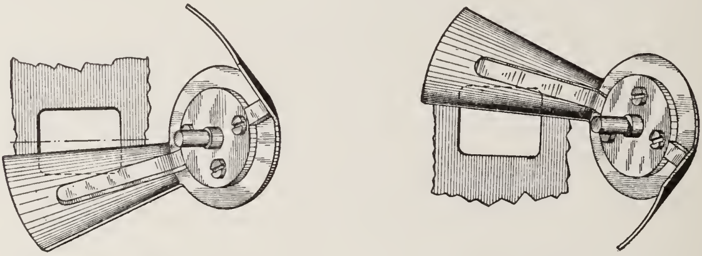


Fig. 56. Fig. 57.

Motiograph Shutter in Two Positions

Tighten the screws firmly, after which revolve the mechanism until the inner shutter is at the original position, that is, the upper edge of the large wing should be about 1/16 inch below the center of the aperture plate. Replace the outer shutter on the shaft, tighten the screws partially in the same manner as was done with the inner shutter, set the lower edge of the large wing about 1/16 inch above the center of the aperture plate, after which tighten the screws firmly, Figs. 58 and 59.

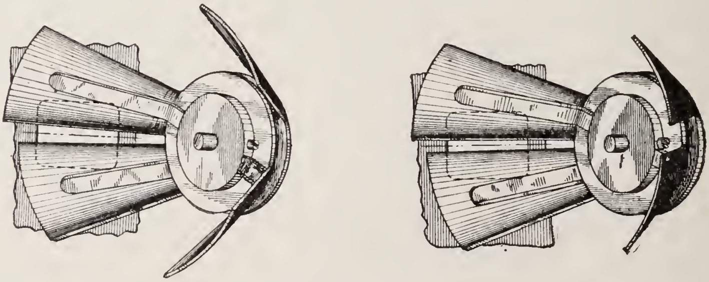


Fig. 58. Fig 59.

Motiograph Double Shutter in Two Positions of Adjustment

After the setting of the shutters has been once done, it will be very simple and easy to repeat.

The width of the shutter wings that will be furnished, unless otherwise ordered, will be that known as the 36-degree wings, which are best adapted to distances from 60 to 100 feet or more. The 36-degree wings are narrower than the 42-degree wings and give the greatest possible amount of exposure as compared with the non-exposure. On distances less than 60 feet, and especially where brilliantly-colored announcements are used, such as a brilliant red, there is liable to be a slight ghost of color above and below the announcement. Also where there are plain whites in the picture, with heavy backgrounds around them, there is liable to be a slight ghost.

These defects being so slight are, to most exhibitors, not objectionable in view of the advantage of a greater amount of exposure, but where they are, they may be entirely overcome by use of the 42-degree shutters, the wings of which are wider than the 32-degree.

To Set the No. 2 Motiograph Shutter. Remove front plate which carries lens, loosen screws in shutter just enough so shutter can be easily turned on the shaft. Take hold of the balance wheel, revolve mechanism in same direction as during operation of the machine, observe when the intermittent sprocket starts to move and set lower edge of shutter at bottom edge of aperture. Turn the balance wheel until the sprocket stops, at which time the top edge of shutter should be on a line with the top edge of the aperture. When properly set, tighten the screws in shutter.

Lenses of shorter focus than about 2¾ inch cannot be used to advantage with the regular Motiograph double or single cone shutters, and when lenses of shorter focus than about 2¾ inch are to be used, we recommend the use of the *Auxiliary front intermittent shutter No. 3,* which may be attached to and used with the No. 1A mechanism, the first of which were placed on the market in April, 1910. With this form of shutter there is no limit and lenses of as short focus as may be desired can be used. Extreme short focus lenses should never be used where the machine could be set at a point where longer focus lenses can be used, and especially where the machine is to be located considerably above or below a line that would be parallel with the center of the screen, because at best, an extreme short focus lens requires the greatest possible care in focusing and when located at a considerable distance above or below a line that would be parallel with the center of the screen, it will not be practicable to get a sharp focus on all parts of the picture.

To Attach the Auxiliary Front Intermittent Shutter No. 3. The auxiliary front intermittent shutter No. 3 is used in front of the lens. It is mounted on a front plate, which is to be used in place of the regular front plate that comes with the Motiograph Model No. 1A. On the shutter shaft is a beveled pinion and for connection with this pinion is a second beveled pinion, which is furnished with the shutter and front plate. This second beveled pinion is to be attached to the shutter drive shaft on the inside of the mechanism, by first removing the larger beveled gear that is attached to the shutter drive shaft. These beveled gears are held on the shutter drive shaft by a single screw. There is a steel plate attached to the center of the gear, on which there is a tongue which engages with a groove of the same size in the shutter drive shaft. Care should be exercised that the tongue is properly engaged with the groove in the shaft before tightening the screw. When using the front shutter, the wings of the regular cone shutters, No. 1 and No. 2, should be removed.

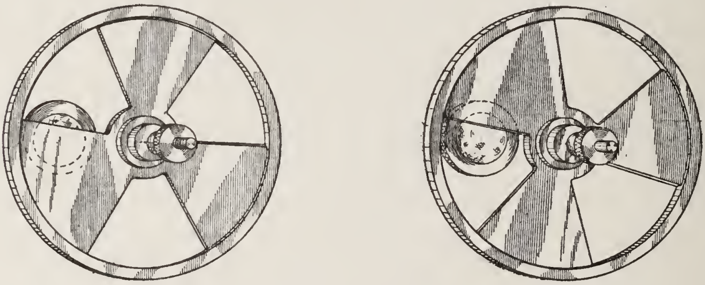


Fig. 60 Fig. 61
Before the Lens Shutter in Two Positions of Adjustment

To Set the No. 3 Shutter. Place the shutter on the shutter shaft, as shown in Fig. 55. It is held in place on the shaft by a thumb nut on the end of the hub. The shutter consists of three wings, one of which is larger than the other two. The large wing is intended to cut off the light while the film is in motion and the other two serve as interrupters for the reduction of flicker. To set the shutter in time with the intermittent film sprocket, loosen the thumb nut on the hub of the shutter, take hold of the balance wheel and turn the mechanism very slowly in the same direction as when in operation until the intermittent sprocket begins to move. Set the top edge of the large wing so it is about ¼ of an inch above the center of the lens, Figs. 60 and 61. Now turn the balance wheel until the intermittent sprocket stops, then see that the lower edge of the large wing of the shutter is about ¼ of an inch above the center of the lens. The shutter should be set as far back on the shaft as is practicable, that is, not to exceed about ½ inch from the front of the lens mount. When properly located tighten the thumb nut on the shutter hub. When long focus lenses are to be used, the shutter may be reversed on the shaft, that is, the hub and thumb nut placed at the rear. This will make it possible to set the shutter well to the front, so as to pass in front of a long focus lens.

When using alternating current of 60 cycles, two interrupters may be objectionable, owing to the fact that at times the alternation of the current is liable to run synchronously with the interrupters in the shutter in such a way as to very largely cut down the illumination. Where this condition exists, the only remedy is to use a shutter having but one interrupter.

INDEX OF PARTS FOR THE MECHANISM OF THE NO. 1A MOTIOGRAPH MODEL 1910, FIGS. 62 TO 67 INCLUSIVE

1A	Main frame of mechanism
2A	Base
3A	Gear cover
3½A	Gear cover for motor pulley and idler
4A	Bridge
05A	Framing device (vertical part)
06	Framing device (horizontal part)
7A	Upper reel arm—casting only
8	Upper reel arm cap
9A	Lower reel arm
10	Arm idler tension
11A	Framing lever
12A	Main clamp thumb wheel and screw
13A	Crank without handle
013A	Crank handle complete
14	Balance wheel
15A	Main gear
16A	Gear and pinion between crank shaft and balance wheel pinion
17A	Gear on lower sprocket shaft
18A	Gear between balance wheel shaft and lower sprocket shaft
19	Governor crank complete
20	Small belt pulley and screw
21	Large belt pulley and screw
22	Lens mount ring
23	Intermittent roller bracket
24	Roller bracket, top, with arbors
25	Roller bracket, bottom
26	Spider for fireproof magazine
028	Bushing for intermittent sprocket arbor
29	Magazine latch, large piece
30	Magazine latch, small piece

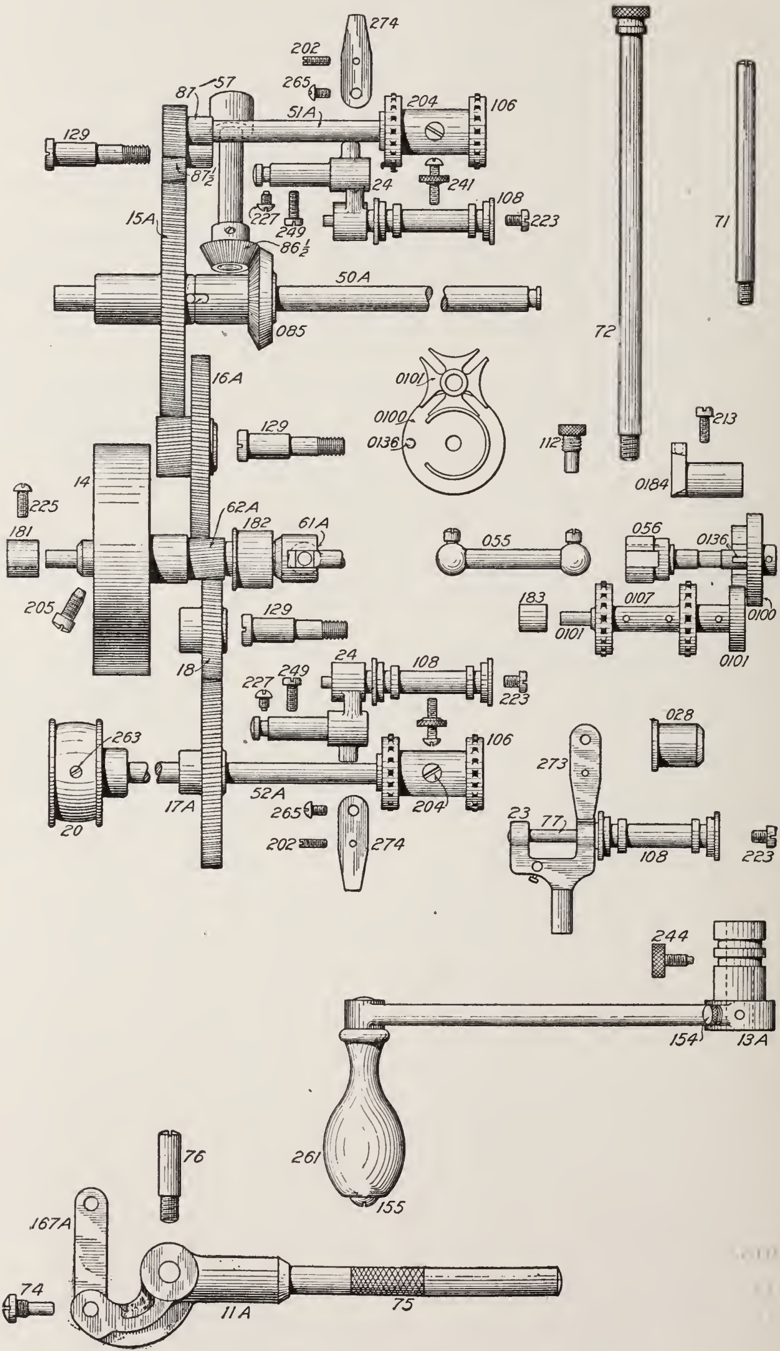


Fig. 62. Motiograph Parts

31-32	Magazine hinge
33	Fire trap, casting only
33ct	Fire trap, complete with rollers
37	Lens arm bracket
38A	Shutter arbor and pinion, solid
39A	Shutter arbor and pinion, main, hollow
40A	Governor drive shaft
41A	Shutter drive shaft screw
42A	Bushing for governor drive
43A	Screw for intermittent sprocket
44A	Screw for gear on upper sprocket arbor
45A	Bevel gear on shutter drive shaft
46A	Bevel gear on shutter shaft
47A	Intermediate pinions in gear case
48A	Screw for clamping shutter wing
50A	Crank arbor with pin
51A	Upper sprocket arbor
52A	Lower sprocket arbor
055	Ball arbor
056	Knuckle joint socket on Geneva arbor
57	Reel arm socket arbor
58	Reel arm vertical arbor
59A	Reel arbor, upper
60A	Reel arbor, lower
61A	Balance wheel arbor and socket
62A	Balance pinion and sleeve
63	Upper fire shield
64	Lower fire shield
65	Governor arbor
65G.C.	Governor complete
69A	Bushing for shutter drive arbor
71	Framing device guide rod
72	Framing device slide rod and head
74	Framing lever joint screw
75	Framing lever handle
76	Framing lever fulcrum screw
77	Intermittent roller bracket joint pin
80A	Bushing for gear case (rear)
83	Governor crank arbor
84A	Gear on governor drive shaft
085	Bevel gear on crank arbor
86	Bevel pinion on upper reel arm arbor
86½	Bevel pinion on rewind socket arbor
87	Gear on upper sprocket arbor
87½	Intermediate gears, small
89	Bevel gear on reel arm vertical arbor
90	Gear on governor arbor, and hub
91	Stereopticon slide rod
91½	Stereopticon slide rod, nut, and washer
92A	Screw to locate gear case
93A	Screw to retain gear case
94	Push rod for reel arm
95	Locking pin for rewind shift
96A	Film tension jaws, each
97A	Heat arrester gate
99A	Thumb screw for front plate
0100	Geneva driver and arbor, complete
0101	Intermittent sprocket arbor and star
102	Screw for eccentric bushing, framing device
103A	Screw to retain shutter drive bushing
105A	Cap for hole in foot of main frame

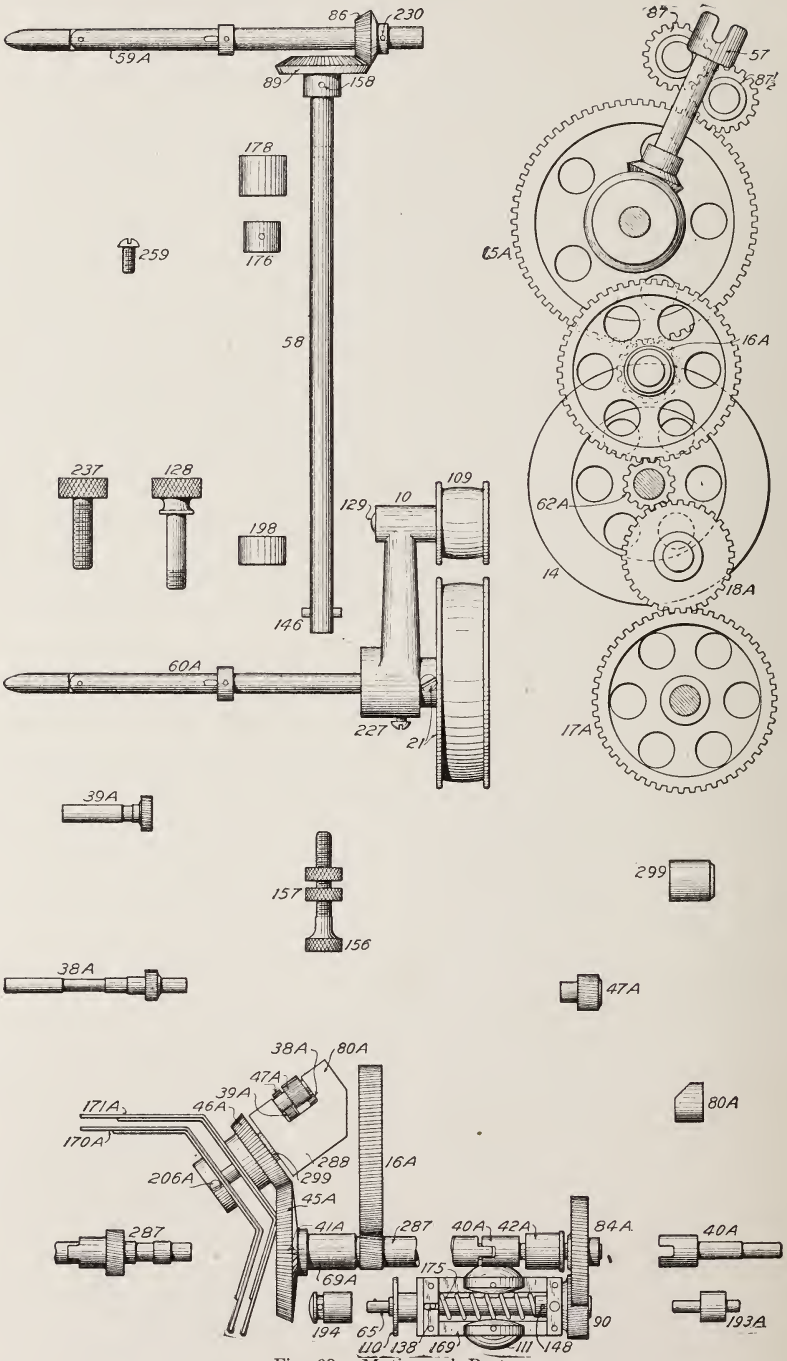


Fig. 63. Motiograph Parts

106	Sprocket, upper or lower
0107	Intermittent sprocket
108	Film rolls
109	Idler pulley
110	Roller guide on governor shaft
111	Governor balls
112	Oil cup
114A	Gear casing for shutter, complete with gears
116	Roller, top of door (2 rolls and shaft)
117A	Locating plunger for crank handle
118A	Spring for locating plunger
119	Center pin in hinge of fire magazine
120A	Side plate
123	Collar on door latch rod
125	Door latch rod
126	Door roller pin
127	Ball screw and door hinge
128	Screw for upper and lower reel arm
129	Screws for gear and idler
133	Pin in governor arbor
135	Pin for motor drive
0136	Pin in Geneva driver
146	Pin reel arm vertical arbor
148	Pin in gear on governor arbor
154	Screw in crank
155	Screw in handle of crank
156	Adjusting screw on take-up idler
157	Check nut on take-up idler
158	Pin in vertical reel arbor gear
160A	Door plate
162A	Aperture plate
163	Brass shutter and pinion
164A	Heat arrester
165	Stripper plate
167A	Connecting bar for framing device
168	Rack for fire shutters
169	Governor strips, each
170A	Shutter wing (outer) with collet and screws
171A	Shutter wing (inner) with collet and screws
172	Front plate
174A	Film tension spring
175	Governor springs
176	Collar on reel arm vertical arbor
178	Large bushing vertical reel arbor
181	Bushing for balance wheel arbor, small
182	Bushing for balance wheel arbor, large
183	Small bushing for intermittent sprocket shaft
0184	Eccentric bushing for framing device
193A	Bushing in bridge for governor shaft
194	Bushing in frame for governor shaft
198	Bushings in reel arm (small)
200	Screw in governor crank
202	Locating screw for idler bracket spring
203	Screw for Nos. 23, 24, 25
204	Screws for sprockets, upper and lower
205	Screw for balance wheel
206A	Screws for shutter collet
207	Screws for upper reel arm cap
208	Locating screw for front plate
209	Screws to fasten magazines to spiders
210	Screws for spring on framing device

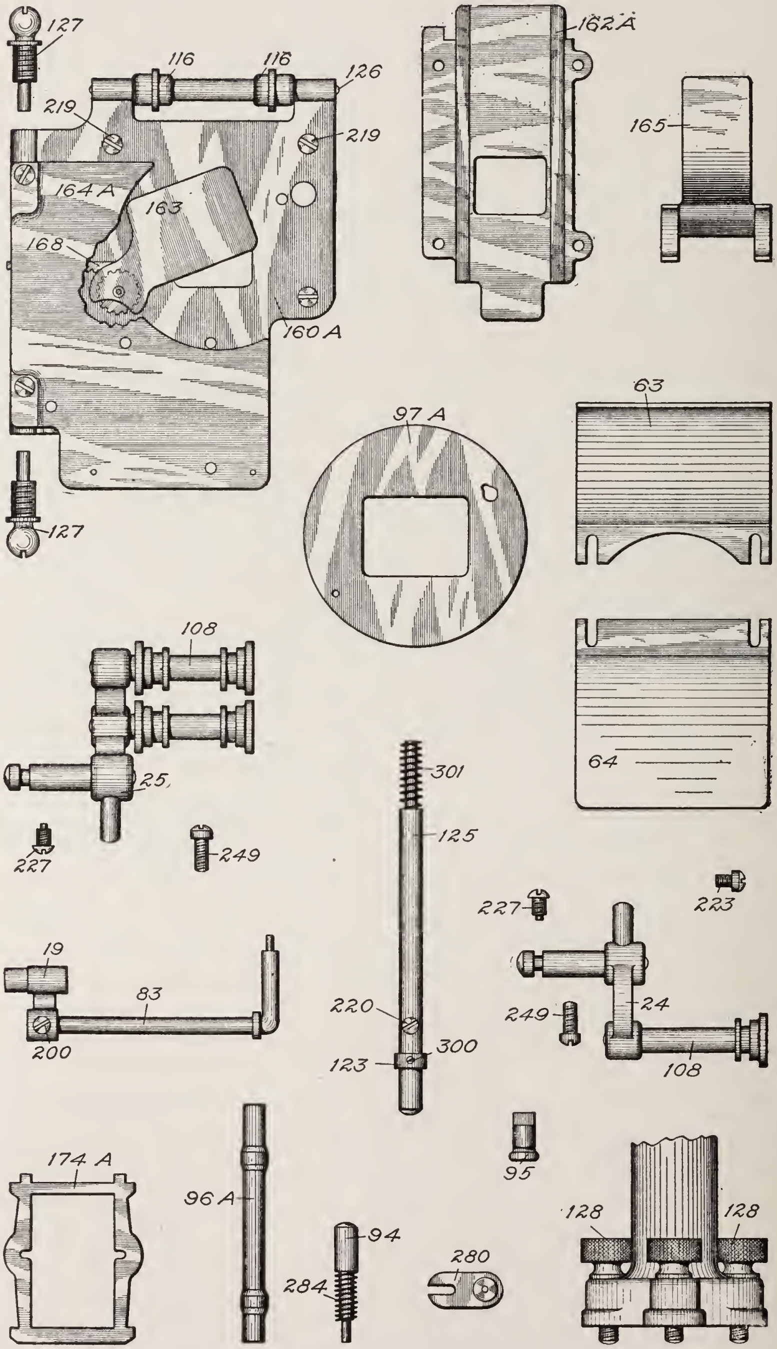


Fig. 64. Motiograph Parts

211	Screws for stripper plate
213	Screws for small bushing, framing device
214	Screws for large bushing, framing device
215	Screws for framing device cap
224A	Screws for bridge
225	Screws for bushing in bridge
227	Locating screw for idler tension arm
228	Screw for bushing in governor shaft

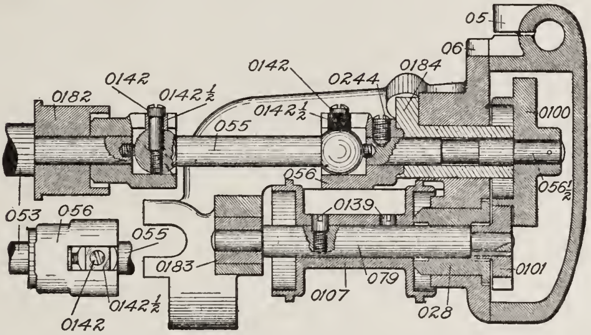


Fig. 65. Motiograph Framing Device Parts Assembled

216	Screws for friction on vertical rod
217	Screws for aperture plate
218	Screws for fire shields
219	Screws for studs on door
230	Screw in reel arbor bevel pinion
231	Upper screw for gear cover
232	Left side screw for gear cover
233	Right side screw for gear cover

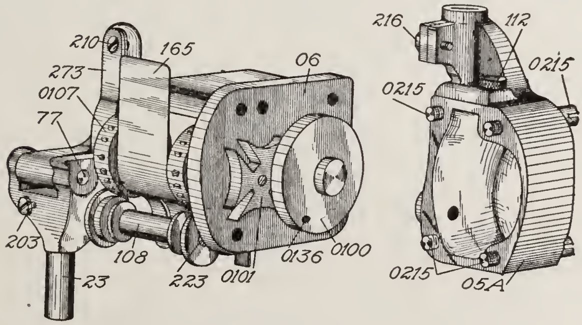


Fig. 66. Parts for No. 2 Motiograph Mechanism

220	Screws for door latch
221	Screws for tension springs
222	Screws for stop on door
223	Screws for roller arbors
235	Screw for holding bushing in frame
237	Screw for attaching magazine to reel arm

238	Magazine body and cover
241	Check nut on roller bracket
244	Screw for locating crank-handle
245	Set screw in socket arbor
246	Screw in roller bracket
248	Safety cap for crank arbor
249	Screw to hold roller bracket in place
251	Roller for fire trap, plain
252	Roller for fire trap, with flange
253	Pins for roller arbor
254	Tension plunger in fire trap
255	Screws to hold traps to magazines
256	Screws for fire trap
257	Screws for nut on reel arbor
258	Spring for pressure rollers in fire trap
258½	Spring for gate latch
259	Set screw to bind bushing in reel arm
261	Wood handle for crank
262	Screws to check guide rod
263	Screws for small belt pulley
265	Screws for roller bracket springs
267	Screws for framing device bushing
268	Screws in magazine latch
273	Springs for framing device (2 pieces)
274	Springs for roller bracket (3 pieces)
275	Springs for front plate (2 pieces)
276	Set screw for large bushing on balance arbor
277	Take-up belt
284	Spring for push rod
285	Balance arbor screw
286	Motor drive arbor
287	Shutter drive arbor and pinion
288	Gear case
289	Screws for bushing in gear cases
290	Arbors for intermediate gears in gear case
291	Screw in gear on lower sprocket arbor
292	Adjusting screw for eccentric bushing in framing device
293	Screw for socket Geneva arbor
294	Screw for upper fire shield
295	Latch pin for side plate
296	Nut for latch pin
297	Spring for latch pin
298	Screws for side plate
299	Bushing for gear case (front)

MOTIOGRAPH No. 1A ARC LAMP

MG 1	Burner slide
MG 1¼	Machine screws
MG 3	Main body
MG 3¾	Main body stud to hold upper castings
MG 4	Lower horizontal casting
MG 4¼	Stud
MG 4½	Lower horizontal casting stud
MG 4¾	Roller
MG 5	Upper horizontal casting
MG 5½	Upper horizontal casting stud
MG 9	Carbon clamp, complete; long (1)
MG10	Carbon clamp, short
MG11	Upper carbon clamp bracket
MG12	Upper rack bracket
MG16	Lower carbon clamp bracket
MG17	Lower rack bracket

SCENE FROM PHOTOPLAY, "HEARTS AND FLAGS"
Courtesy of *Thomas A. Edison, Inc., Orange, N. J.*

MG18	Upper rack
MG19	Lower rack
MG20	Screw for lower horizontal casting
MG22	Rack plate
MG22½	Screws
MG23	Rack pinion and arbor
MG24	Rack pinion ball, joint and pin
MG24	Rack pinion ball screw
MG25	Shaft to operate racks, complete
MG39½	Swivel screw for up and down adjustment
MG40	Socket
MG40½	Ball joint screw
MG40¾	Pin
MG41	Shaft for up and down adjustment, complete
MG46	Wood handle on up and down adjustment
MG46½	Screw for wood handle
MG47	Plate on lower carbon clamp

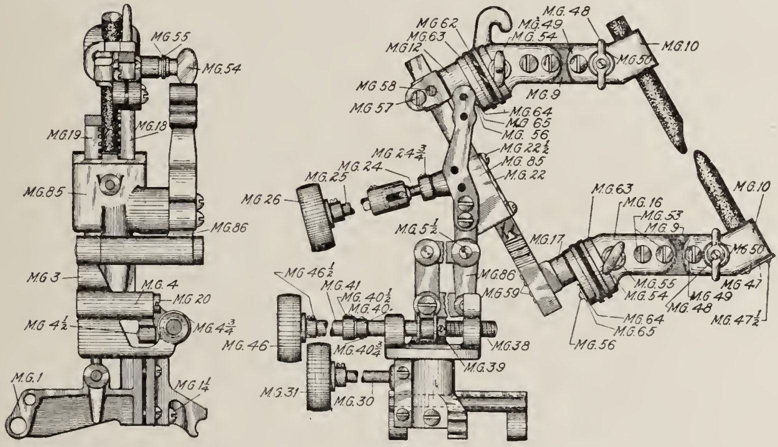


Fig. 67. Parts for Motiograph No. 1A Arc Lamp

MG26	Wood handle for shaft racks
MG26½	Screws for wood handle, rack shaft
MG30	Shaft for side adjustment, complete
MG31	Wood handle, side adjustment
MG31½	Screw for wood handle
MG32	Swivel collar for side adjustment
MG33	Screw to hold swivel collar
MG34	Washer on side adjustment shaft
MG38	Screw for up and down adjustment
MG39	Swivel for up and down adjustment
MG47½	Screws for plate
MG48	Wing nuts for carbon clamps (2) ¼×24
MG49	Machine screws to hold short clamps (2) 10×24
MG50	Washers for short carbon clamps
MG53	Machine screws to hold long clamp to bracket (4) ¼×24
MG54	Thumb screws to hold wire, (2)
MG55	Washers for No. 54 (4)

MG56	Machine screws to hold brackets
MG57	Machine screws to hold upper bracket on rack, (1) 10 × 24
MG58	Machine screws to hold upper rack on bracket (1) 8 × 32
MG59	Machine screws to hold lower rack on bracket (2) 8 × 32
MG62	Mica insulators—flat—set
MG63	Mica insulators round bushing
MG64	Mica insulators round washers
MG65	Iron washers for M.G. 56
MG75	Main body No. 2 and stud (for use on No. 2 Motio)
MG80	Shaft for No. 2 up and down adjustment, complete (for use on No. 2 Motio)
MG85	Rack body (new style)
MG86	Bracket for rack body (new style)

UPPER CARBON ADJUSTMENT FIXTURE

MG91	Rack bracket for adjustment fixture
MG92	Adjustment bracket for carbon clamp
MG93	Support bolt
MG94	Adjustment screw
MG95	Adjustment handle
MG96	Clamp bolt
MG97	Collar for adjustment screw
MG98	Stock washer $\frac{9}{16} \times \frac{3}{32}$ inch
MG99	Stock screw—round head, 8-32 × $\frac{1}{4}$ inch
MG100	Pin for collar for adjustment screw $\frac{3}{32} \times \frac{1}{2}$ inch
MG101	Headless screw for adjustment thumb nut

UPPER UNIVERSAL CARBON CLAMP

MG110	Bracket (long)
MG111	Clamp screw for bracket
MG112	Locating screw for bracket
MG113	Swivel for bracket
MG114	Clamp screws for swivel
MG115	Washers for clamp screws for swivel
MG116	Carbon holder
MG117	Wing nut for carbon holder

LOWER UNIVERSAL CARBON CLAMP

MG118	Bracket (long)
MG119	Clamp screw for bracket
MG120	Locating screw for bracket
MG121	Swivel for bracket
MG122	Clamp screw for swivel
MG123	Washers for clamp screws for swivel
MG124	Carbon holder
MG125	Wing nut for carbon holder
MG126	Stop plate on carbon holder
MG127	Screws for stop plate

POWER'S NO. 5 CAMERAGRAPH

The Power's No. 5 cameragraph is a projecting machine which has been well known for several years. The right side, or crank side,

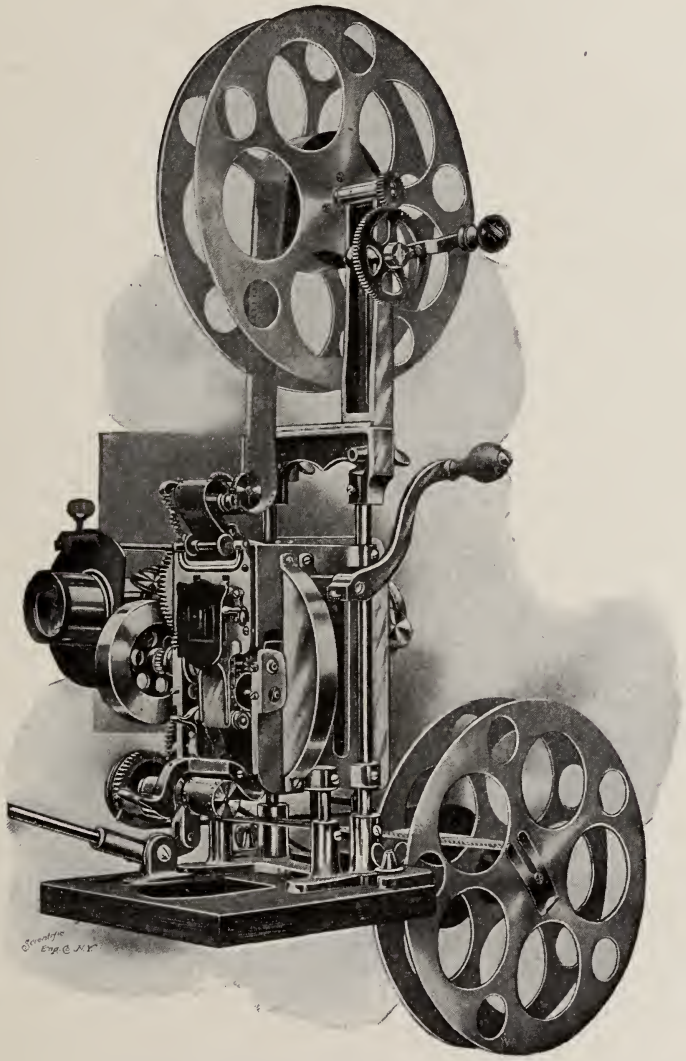

Scientific Eng. Co. N.Y.

Fig. 68. Crank Side of Power's No. 5 Cameragraph

of the motion-head mechanism of the No. 5 model is shown in Fig. 68, while the reverse, or left side, is shown in Fig. 69. In the illustrations, the motion head is equipped with an upper reel hanger, holding an open reel for the feed reel of film, instead of the iron fireproof magazine. By the turning of two thumb screws, the upper reel hanger may be lifted off and the fireproof magazine hung in

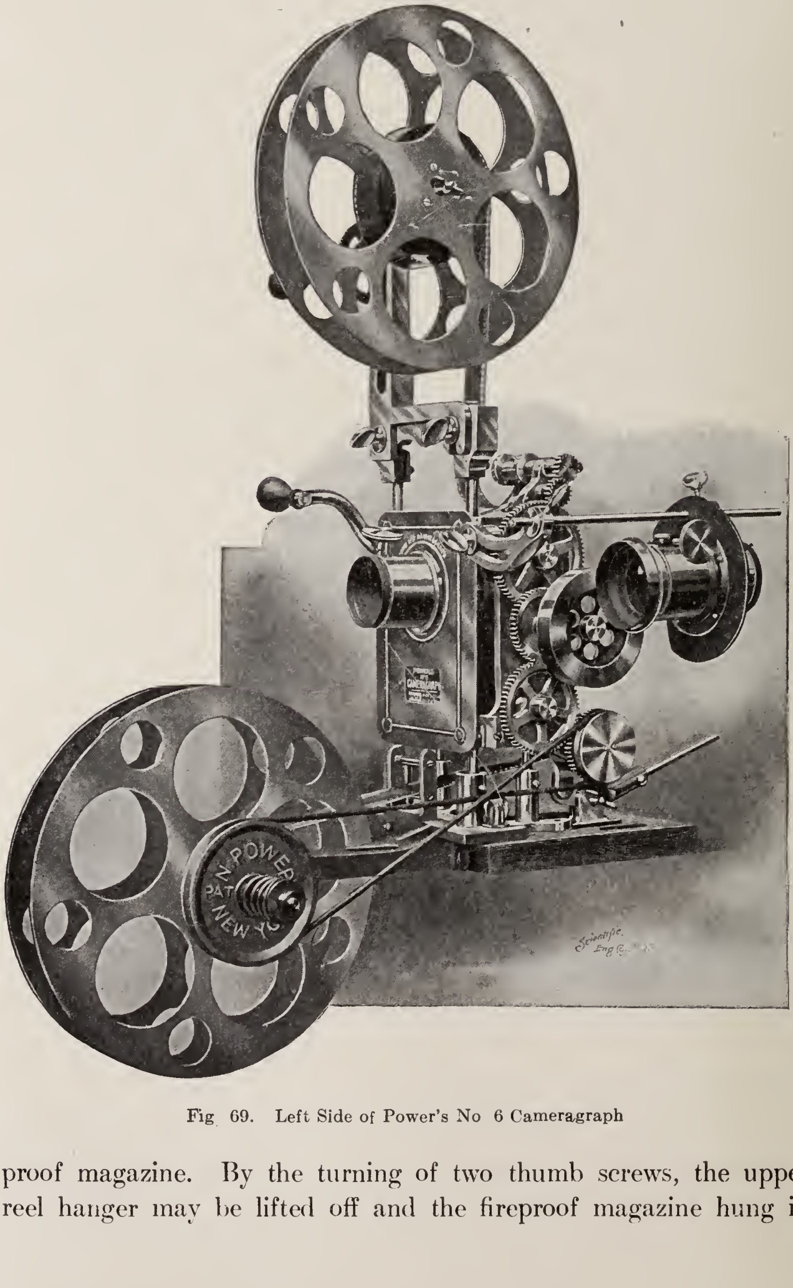


Fig. 69. Left Side of Power's No 6 Cameragraph

its place. This furnishes a convenience in packing, and in working about the motion head to clean it up before beginning the evening's run of the show.

The intermittent mechanism is the standard three-sprocket type, upper steady feed, intermittent sprocket at the film gate, and lower steady feed below. The intermittent (in the No. 5 mechanism) is driven by the Geneva form of drive, kept in balance by a heavy fly wheel mounted directly upon the pin shaft of the intermittent mechanism. The four-slot Geneva star and one-pin cam is used, and the mechanism is timed to about $\frac{1}{4}$ motion and $\frac{3}{4}$ rest for each picture.

The shutter of the No. 5 model is within the motion head, mounted very close to the film window. It projects near the crank handle of the motion head, and is covered by the curved shield seen near the handle in Fig. 68. The shutter is of the so-called "balanced" or multiple wing type, two wings being used, the broader one covering the aperture during the shift of the film and the narrower one being introduced to reduce the flicker.

The framing mechanism is a sliding carriage on the main body of the motion head; it carries the intermittent sprocket, the pin wheel, and the star wheel, and it is shifted by a short framing lever having a toggle joint with the carriage.

An ingenious arrangement of gearing is provided by which a constant meshed gear connection is maintained between the crank shaft—which is mounted rigidly in the main body of the motion head—and the Geneva movement, which is carried movably by the framing carriage. A spur gear on the main body and a spur gear on the pin-wheel shaft of the framing carriage have an idler spur wheel between them, the idler being hung upon a pair of movable arms which keep it at all times meshed with both of its meshing gears in the train.

The presser rollers by which the film is kept in engagement with the feed sprockets are all mounted in pivoted brackets, controlled by springs, and are provided with set screws by which the rollers may be adjusted to the sprockets to secure proper control of the film.

The aperture plate is provided with hardened steel guide strips on its face for guiding the film. On the film gate, in front of the film window, and on the lamp-house side, is a heavy plate called a "cooling" plate, apparently having no function in the operation of the machine, but its purpose is to prevent the rays of the lamp from shining directly upon the film gate and heating it to a high degree which would endanger the film.

The upper reel hanger is provided with a rewind handle, hence it is not necessary to detach the main drive handle or move it to a new position to rewind the film. The rewind handle does not engage the feed reel until pushed in upon its shaft, so it does not interfere with the turning of the feed reel during the unwinding of the film for projection.

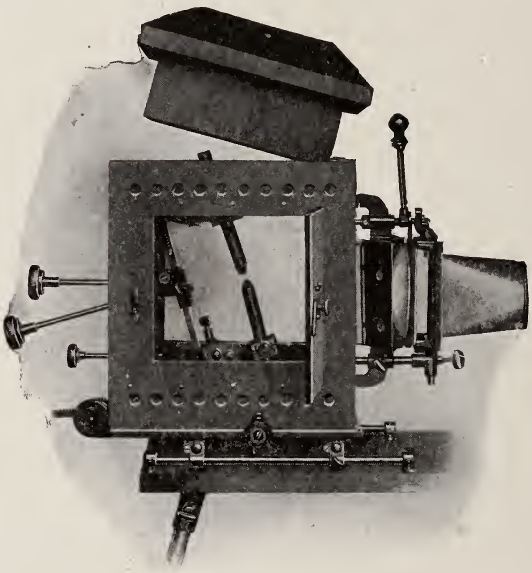
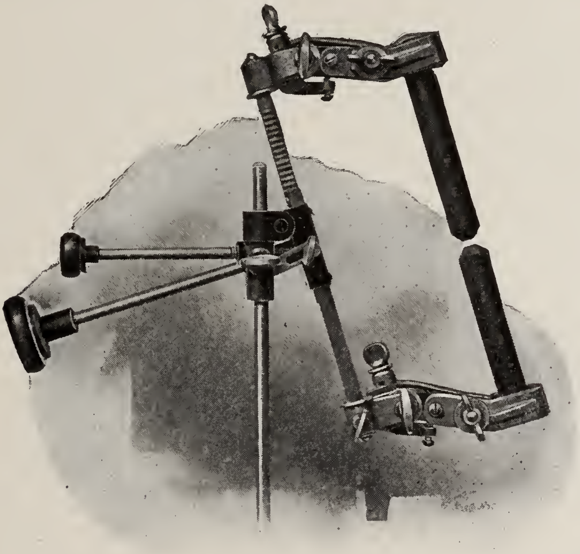


Fig. 70 Cameragraph Lamp House, No. 5 Model

The lamp house slides upon a double rod track to pass from the motion head to the stereo lens, or *vice versa,* and this double-rod cross track in turn slides upon a pair of rails or rods upon the projection table which enables the lamp house to be placed at any desired distance from the motion head and stereo lens, thus affording every facility for the projection operator to get his condensers and his lens into proper focal relation with each other. The lamp house and its double arrangement of cross tracks is shown in Fig. 70.

The lamp is a two-knob lamp, easy for the beginner to control during the projection of the pictures, because he is not likely to turn the wrong knob and throw out a carefully adjusted screen illumination. The lamp is shown in Fig. 71. The larger knob is the feed knob, by which the arc is struck and the carbons are fed down as they burn away during projection. The smaller knob is the tilting knob, by which the lamp frame of the lamp, including the feed rods, carbon clamps, and carbons, is tilted up or down, according as the knob is turned, to bring the arc into proper center with the condensers. The proper distance of the arc from the condensers and the proper transverse or side adjustment of the lamp is made inside the lamp house, through the door. The height is made by the sliding block and set screw which clamps it to the vertical rod of Fig. 71, upon which the lamp frame is mounted. The distance from the condensers forward or back in the lamp house is made by moving the base of the vertical rod, in the house, but in some of these lamps there is a third knob projecting at the very bottom of the lamp house at the back, and the lamp may be slid toward or from the condensers by turning this extra knob, which is so low that it is not likely to be



[Fig. 71. Cameragraph Lamp, No. 5 Model

touched by accident during projection. The design of the Power's lamp and lamp house is such as to avoid accidental moving of parts which should be left alone during projection.

The top of the Power's lamp house is hinged, and may be swung upward to afford convenience in setting the carbons, the operator passing one hand through the top of the lamp house and the other through the door.

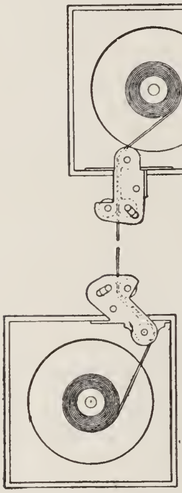


Fig. 72. Cameragraph Film Outlet and Fire Trap

The lamp house also has the douser shutter between the condenser and the lantern slide, instead of at the end of the condenser hood, thereby protecting the slide when not being projected.

The fireproof magazines for feed and take-up reels are provided with a special type of roller fire trap, shown in Fig. 72. It will be noticed that one of the rollers of the fire trap has its shaft projecting at both ends. In feeding the film end through the trap, the ends of this roller are caught with two fingers and the roller is slid back in its slots to permit the end of the film to pass.

The Power's machines are equipped with two styles of fire shutters. Style *A* is shown in Fig. 73. It is operated by an inward movement of the driving crank upon the shaft. The crank is set upon the shaft with a cam slot and a pin and spring, so that when the power is applied to turn it, it automatically moves inwardly to open the shutter. Style *B* is shown in Fig. 74. This shutter requires that the mechanism have a certain speed of revolution before the shutter will operate to open the film window to the light of the arc lamp, and it is operated by a centrifugal wheel geared to the film driving mechanism of the motion head. Upper and lower film shields are shown in Fig. 74. The lower shield is hinged at the bottom, to permit the operator to get at the mechanism for threading up the film.

Figs. 75 and 76 give illustrations of such parts of the Power's No. 5 Cameragraph as are likely to be needed for repairs, and identify them by number. In ordering a repair part, both name and number should be given.

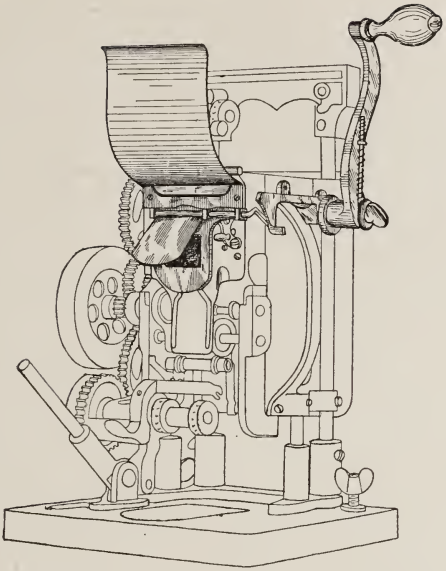


Fig. 73. Cameragraph Safety Shutters, Style A

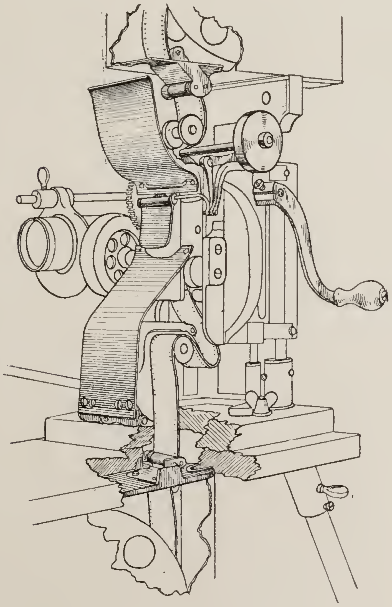


Fig. 74. Cameragraph Safety Shutters, Style B

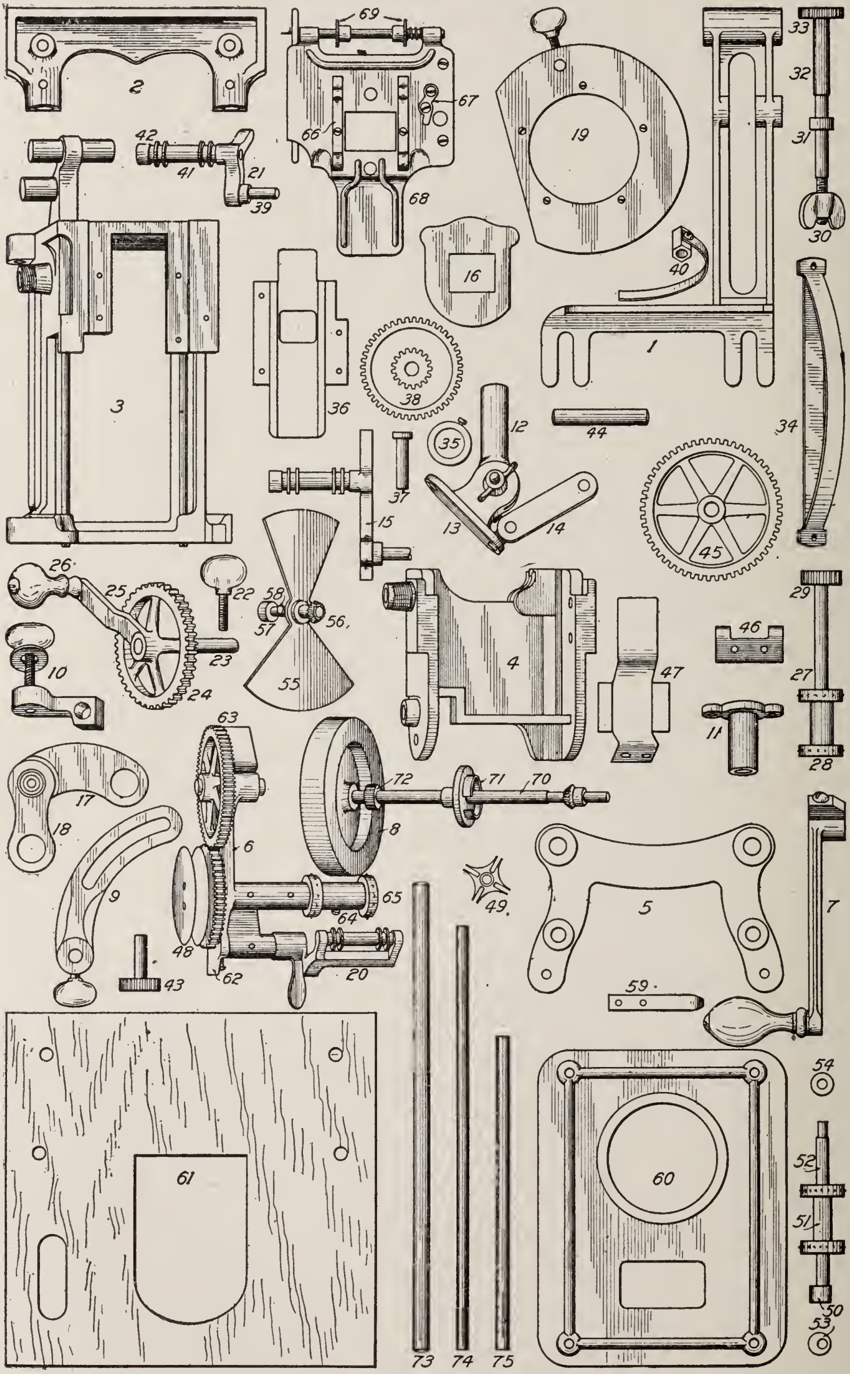


Fig. 75. Parts of No. 5 Cameragraph

INDEX OF PARTS

1 Reel hanger frame
2 Machine top frame
3 Machine body frame
4 Machine framing carriage
5 Machine base casting
6 Take-up feed frame
7 Machine crank
8 Fly wheel
9 Stereo bracket with thumb screw
10 Stereo bracket holder
11 Crank shaft bearing
12 Framing device lever socket
13 Framing device clamp
14 Framing device link for lever
15 Top feed swing bracket
16 Cooling plate
17 Toggle joint, large arm
18 Toggle joint, small arm
19 Stereo flange collar casting
20 Take-up feed roller bracket
21 Intermittent roller bracket
22 Steel thumb screw, nickeled plain
23 Reel hanger shaft
24 Reel hanger gear
25 Reel hanger crank
26 Reel hanger crank handle
27 Heavy feed sprocket
28 Feed sprocket shaft
29 Feed sprocket gear
30 Wing nut
31 Set collar
32 Reel hanger spindle
33 Reel hanger spindle gear
34 Shutter shield
35 Toggle joint set collar
36 Aperture plate
37 Toggle joint spindle
38 Toggle joint gears
39 Intermittent bracket spindle
40 Intermittent bracket spring
41 Intermittent bracket roller
42 Intermittent roller set collar
43 Upper feed gear and spindle
44 Framing lever
45 Crank shaft gear
46 Steel peeler
47 Apron
48 Take-up feed driving pulley
49 Geneva or star wheel
50 Eccentric bushing
51 Intermittent sprocket, light
52 Intermittent shaft or spindle
53 Eccentric bushing (end view)
54 Plain bushing
55 Shutter, revolving
56 Shutter gear, each
57 Shutter set collar
58 Shutter spindle
59 Top feed bracket spring
60 Front plate
61 Base board for mechanism
62 Take-up feed roller bracket spring
63 Gears for take-up feed
64 Heavy sprocket for take-up feed
65 Take-up feed spindle
66 Film tension springs
67 Latch for door
68 Plate door or gate
69 Guide rollers, spindle bushings and springs
70 Pin wheel or Geneva driver
71 Main spindle
72 Steel pinion
73 Machine frame support
74 Machine frame support

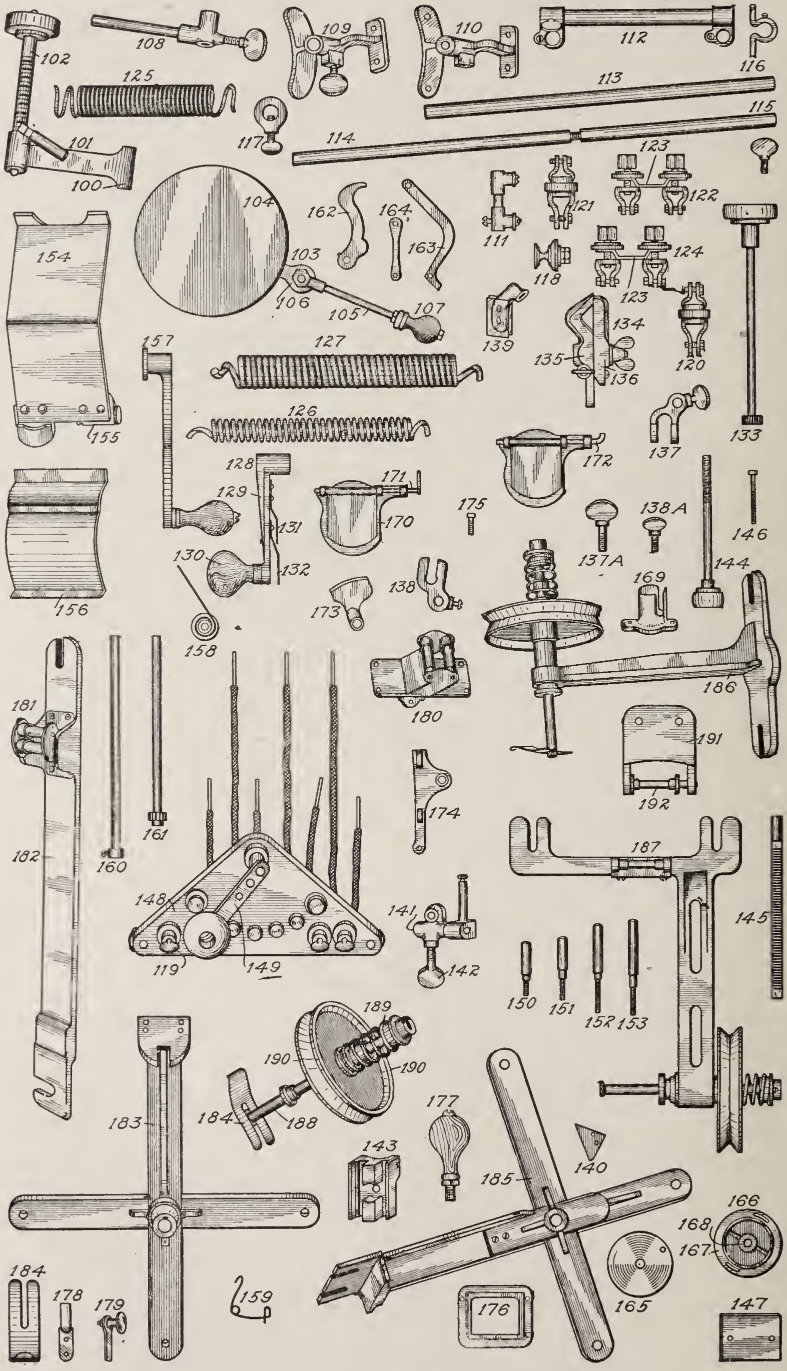


Fig. 76. Parts of No. 5 Cameragraph

75	Stereo lens bracket rod
100	Arc lamp base, complete
101	Arc lamp base casting, with post
102	Arc lamp base adjusting screws and handle
103	Dowser, complete
104	Dowser shield
105	Dowser handle
106	Dowser handle casting
107	Dowser handle knob
108	Funnel support
109	Condenser mount bracket casting, lower
110	Condenser mount bracket casting, upper
111	Rheostat binding post casting
112	Lamp house sliding, sleeve
113	Lamp house sliding rod, longitudinal
114	Lamp house sliding rod, crosswise
115	Lamp house sliding rod, extension
116	Lamp house sliding rod, holder bracket
117	Lamp house stop with thumb screw
118	Binding post for circular rheostat
119	Binding post for 25 amp. rheostat
120	Coil terminal for 25 amp. rheostat
121	Coil terminal for 25 amp. rheostat (end)
122	Coil terminal for circular rheostat (intermediate)
123	Jumper spring for circular rheostat terminal
124	Coil terminal for circular rheostat (double), complete
125	Coil for 120 volt circular rheostat
126	Coil for 25 amp. rheostat
127	Coil for 240 volt circular rheostat
128	Rheostat crank, complete
129	Rheostat crank casting
130	Rheostat crank handle
131	Rheostat crank contact spring, small
132	Rheostat crank contact spring, large
133	Arc lamp rack handle
134	Arc lamp carbon holder, complete
135	Arc lamp carbon holder jaw
136	Arc lamp carbon holder lip
137	Arc lamp carbon holder knuckle lower
137A	Large plain thumb screw for knuckle
138	Arc lamp carbon holder knuckle upper
138A	Small plain thumb screw for lower knuckle
139	Arc lamp carbon holder knuckle bracket
140	No longer used
141	Arc lamp supporting bracket
142	Arc lamp supporting bracket thumb screw
143	Arc lamp adjustment rack guide casting
144	Arc lamp adjustment rack handle, small
145	Arc lamp adjustment rack
146	Arc lamp adjustment rack casting pin
147	Arc lamp name plate
148	Rheostat (25 amp.) adjustment base, complete

149 Rheostat (25 amp.) crank, complete
150 Center post of 25 amp. adj. rheostat
151 Stop spindle on circular rheostat
152 Center post on circular rheostat
153 Upper magazine spindle
154 Lower film shield
155 Lower film shield hinge spring
156 Upper film shield
157 Machine crank for style "A" mechanism
158 Crank spring with button for style "A" mechanism
159 "V" spring for style "A" mechanism
160 Crank shaft for style "A" shutter mechanism
161 Crank shaft and pinion for style "B" shutter mechanism
162 Lever for style "A" shutter
163 Lever for style "B" shutter
164 Lever support for style "B" shutter
165 Friction case cover, style "B" shutter
166 Friction case cover, style "B" shutter
167 Friction shoe, style "B" shutter
168 Friction weights, style "B" shutter, each
169 Crank shaft bearing for style "A" shutter
170 Cooling plate and flap complete for automatic shutters
171 Rock shaft for style "B" shutter
172 Rock shaft for style "A" shutter
173 Left bearing for shaft, style "B" shutter
174 Right bearing for shaft, style "B" shutter
175 Pivot for lever, style "A" shutter
176 Ruby glass frame for lamp house door
177 Wooden knob for lamp house door
178 Catch holder for lamp house door
179 Catch for lamp house door
180 Valve for upper magazine
181 Valve for lower magazine
182 Support casting for lower magazine
183 Cross casting for lower magazine
184 Reel cotter
185 Cross casting for upper magazine
186 Lower take-up attachment
187 Front take-up attachment
188 Take-up spindle
189 Take-up spindle tension spring
190 Split pulley for take-up attachment
191 Guide roller casting for lower take-up attachment
192 Guide roller for lower take-up attachment

POWER'S NO. 6 CAMERAGRAPH

The intermittent movement of the No. 6 model is a radical departure from that of the No. 5 model, and indeed from all previous models of intermittents. It has no pin wheel, no star wheel, no Geneva. It is not a beater, dog, nor claw. Neither is it a friction grip. Two parts are used, similar in relation to the cam wheel and star of the Geneva, but rather reversing the order, since the pin wheel is the intermittent. The driving element is a revolving cam, substantially diamond shaped, upon the face of a heavy steel disk carrying also a steadying or locking band, as is carried by the pin wheel of a Geneva. The driven element is a cross upon the end of the intermittent shaft. In each of the arms of the cross is a pin. The cam band and diamond drive block upon the face of the driving disk are shown in Fig. 77, as are also the cross and pins, separated from their driving and locking elements. The position of the pin cross is shown in dotted lines in the locking band. In manufacture, the cross and pins are cut from a single block of steel. The parts of the intermittent movement are enclosed in an oil-tight casing, with an oil feed cup, and by keeping the casing properly filled with oil a practically noiseless movement of the intermittent drive is assured, Fig. 78.

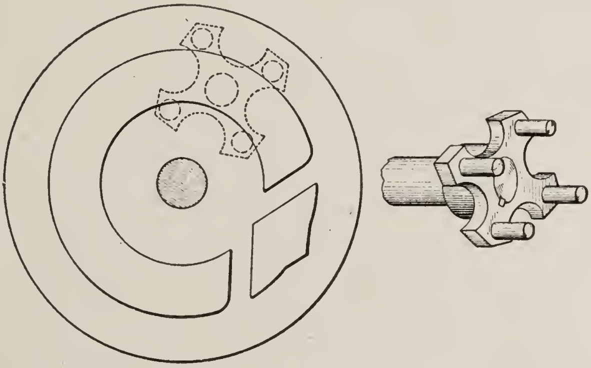


Fig. 77. Intermittent Movement Mechanism, Power's No. 6 Model

The shutter is of the three-wing type, and is mounted upon a spindle which projects forward from the front plate of the motion head, so that the shutter intersects the rays of light in front of the projection lens. The shutter is adjustable longitudinally of the spindle, so that it can be set close to the front of the lens whether a long or short focus of lens is used. The hub of the shutter consists of an inner and outer sleeve; the inner sleeve is directly and permanently attached to the spindle, and the outer sleeve is adjustable upon the inner sleeve to permit quick and accurate setting of the shutter with relation to the intermittent movement. The mountings of the shutter spindle are such that when the shutter is detached for packing the mechanism, the spindle is swung down into close contact with the front of the motion head, where it will be protected from injury in shipment. Owing to the rapid movement of the film produced by the new intermittent mechanism (one-sixth movement and five-sixths rest for each picture interval), the shutter wings may be cut narrower than in most shutters of the three-wing type, thereby giving the screen all possible advantage of the lamp. If the operator does not try to burn his lamp too brightly he should be able to get his flicker well down toward elimination with the No. 6 model cameragraph, but if he tries to crowd on all the light he can from his lamp, the brighter illumination of the screen by the narrower shutter blade will bring back some of the flicker which the rapid film shift endeavors to reduce. The shutter gears are angle gears (not bevel gears), and have faces $\frac{3}{8}$ of an inch in width, thus insuring long service without perceptible wear.

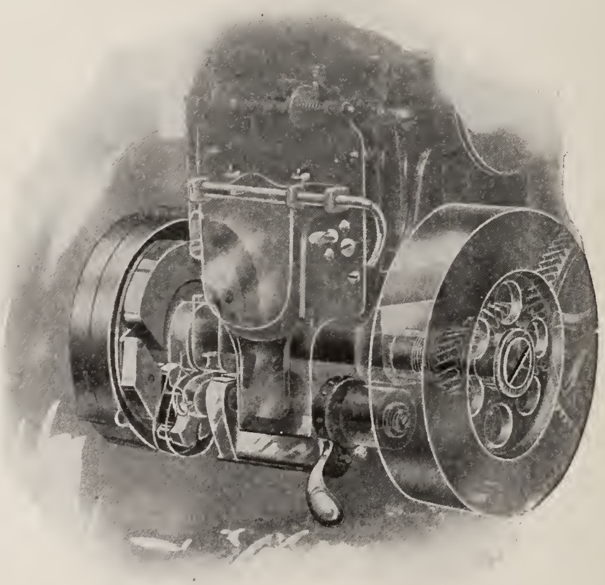
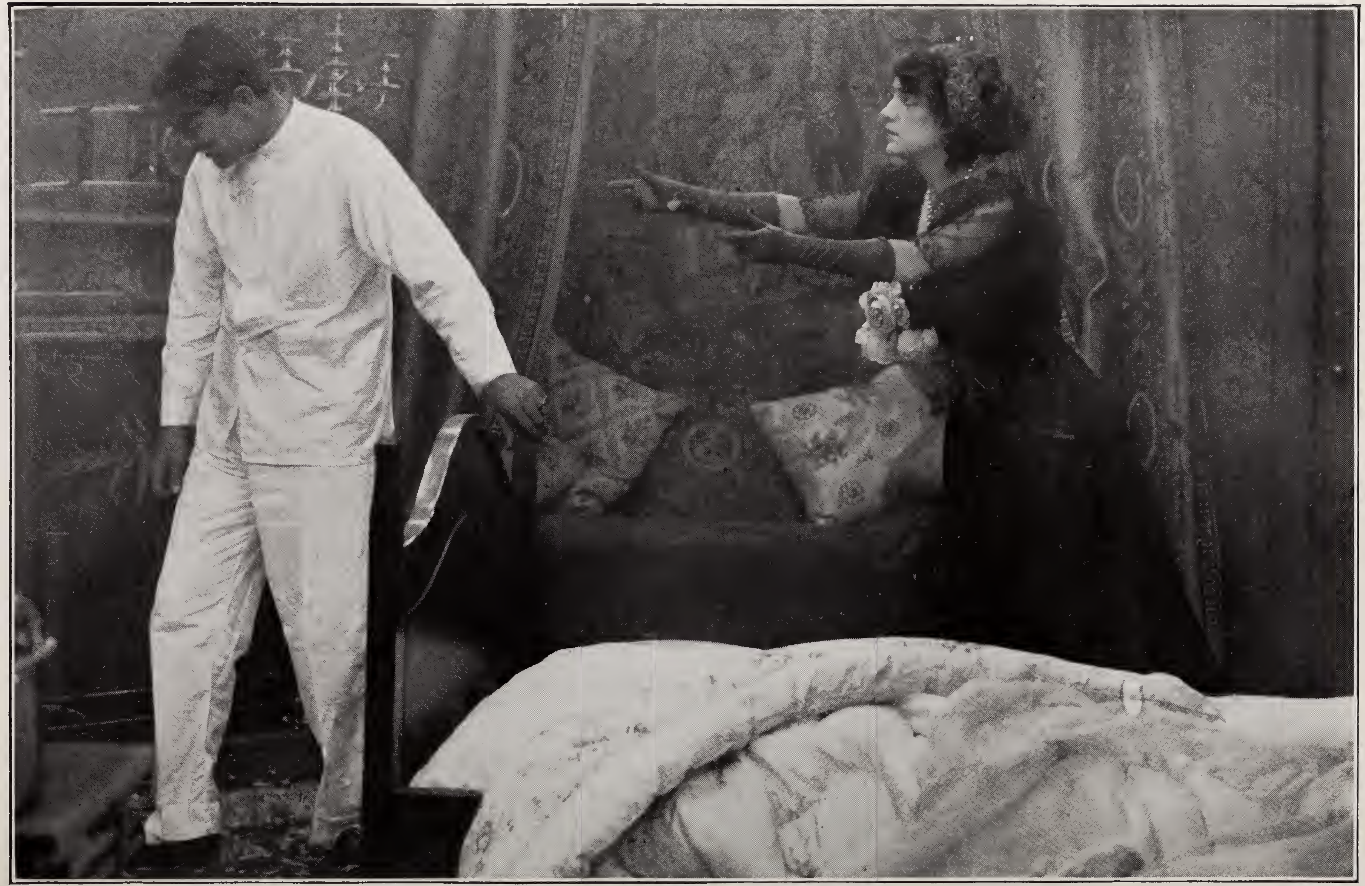


Fig. 78. Complete No. 6 Cameragraph Intermittent Mechanism



SCENE FROM PHOTOPLAY, "HIS MISJUDGMENT"
Courtesy of *Thomas A. Edison, Inc., Orange, N. J.*

The picture is framed by a slight vertical movement of a carriage bearing the intermittent sprocket, and the framing lever is mounted on the base of the mechanism or machine head, where it

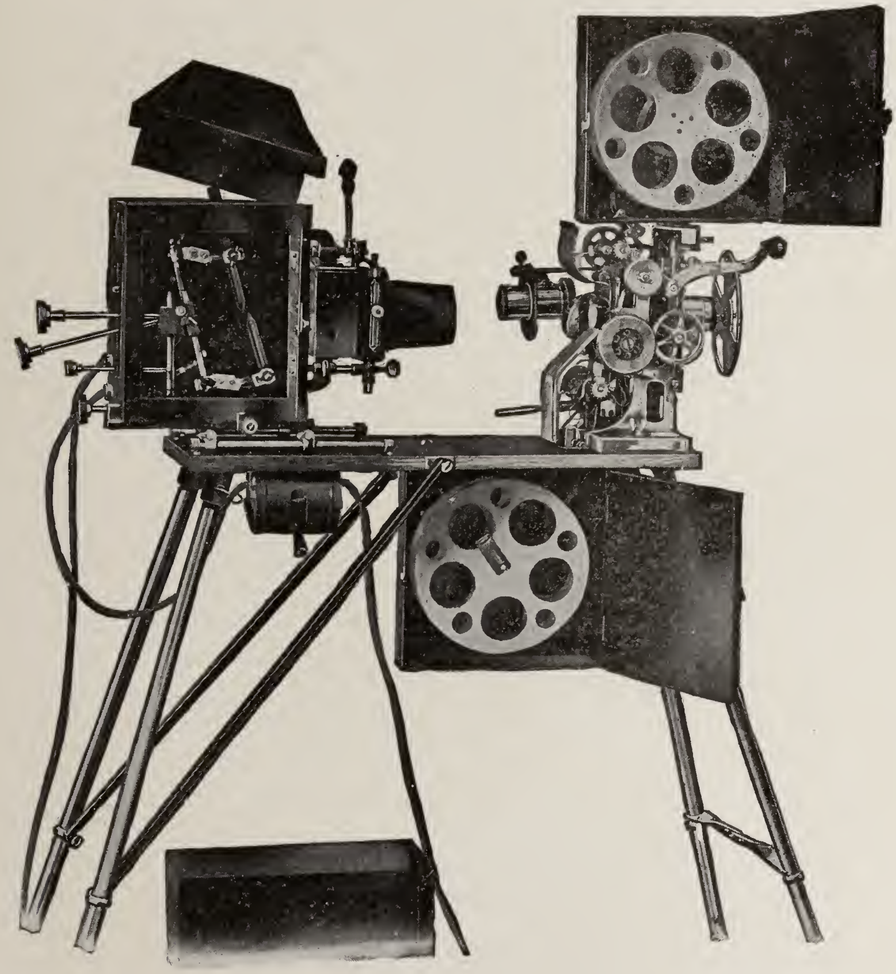


Fig. 79. Power's No.6 Cameragraph

can be readily reached with the left hand without interfering with the operation of the machine. The movement of the framing carriage does not alter the relation of the shutter to the picture gauge or projection aperture. The gearing connection to the framing carriage has all the gears arranged in a straight line, eliminating a toggle joint and toggle joint gears.

The film feed comprises three sprockets in accordance with the usual American practice. The top feed sprocket and the bottom or take-up feed sprocket run constantly, and the middle or intermittent sprocket makes a complete turn in four successive movements with alternate periods of rest, which are four times as long as the periods of movement. All the sprockets are cut from specially selected steel to insure long wear and accuracy of size and form.

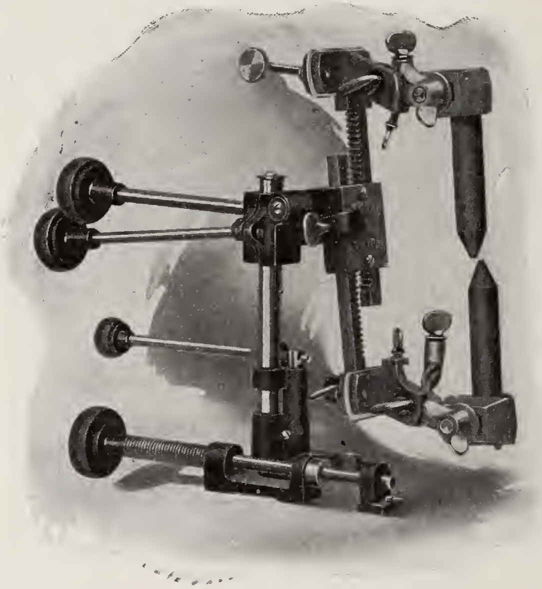


Fig. 80. Cameragraph No. 6 Lamp

The film is held in position upon the top feed sprocket by means of two rollers, one a flanged guide roller turning on a fixed spindle, and the other a holding roller mounted on a spring pressed bracket. The latter roller rests directly over the top feed sprocket when in use and keeps the film in perfect engagement with the sprocket teeth.

The film is held in position on the intermittent sprocket by means of a roller mounted on a pivoted bracket, which is so shaped that it serves also as a guide for the film. When the idler roller for the intermittent sprocket is in service it lies practically under the intermittent spindle and insures engagement of the film with at least four teeth on each hub of the intermittent sprocket.

A pair of idler rollers are provided to keep the film in position upon the lower or take-up feed sprocket, these idlers being mounted in a frame which is arranged to rock on a spindle carried by a spring pressed, pivoted bracket. The lower, or take-up, feed sprocket controls the rate at which the film is taken up in the lower magazine, and it is of the utmost importance that "riding" of the film on this sprocket be prevented. This is completely accomplished by means of the arrangement of idler rollers.

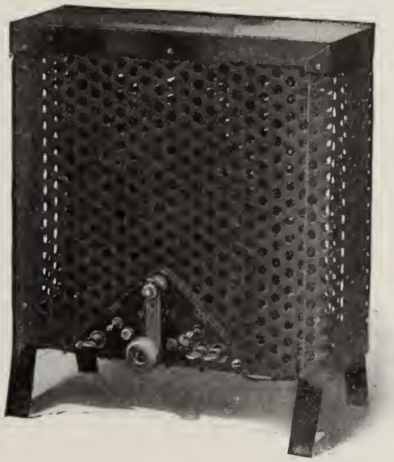


Fig. 81. Power's Rheostat

To prevent wear of the film in traveling over the sprockets, all the idler rollers which hold it in position thereon are so supported that no pressure of the film against the sprockets is produced by the idler rollers, but the possibility of disengagement of the film with the sprockets is completely obviated.

The film guides and friction devices are arranged to make the friction of the film through the motion head as light as possible. At the top of the gate a pair of light flanged rollers are provided through which the film travels to the aperture plate. The tension on the film necessary to insure steady pictures is produced between guide rails or wear strips of hard steel on the aperture plate and a pair of tension springs provided with half-round hardened steel tension contact shoes. To prevent wear on the film in passing from the intermittent sprocket a steel apron with polished surface is provided, over which the film travels with but little friction. The usual safety devices of upper and lower film magazines, fire shields, fire traps in the magazines, film shields, and safety shutter are used in the No. 6 model and are similar to those described in the No. 5 Model Cameragraph.

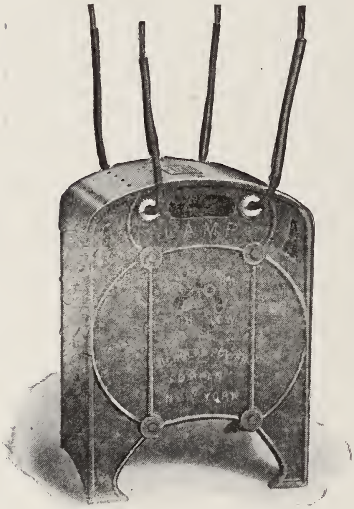


Fig. 82. Power's Inductor

The lamp house of the No. 6 model has its four adjustments outside of the house, the lamp being mounted upon an iron frame inside the house, and being accessible from all sides by reason of doors in both sides of the house and a swinging top upon the house as well.

The No. 6 cameragraph mechanism is shown in Fig. 79, and the No. 6 cameragraph lamp in Fig. 80. The Power's rheostat, which accompanies the Power's projecting machines, is shown in Fig. 81. The knob on the front may be moved to the right or to the left to change the amount of current taken by the arc lamp from the power mains. For alternating current only, the rheostat of Fig. 81 may be replaced by the Power's Inductor Fig. 82, but not for direct current.

PATHE PROFESSIONAL MODEL PROJECTOR

The Pathé projecting machine introduced into America is the type known as their "Professional Model." The Pathé machine differs in one essential respect from all other projecting machines which have reached any wide sale in America, in that it is made entirely in Europe, being made in the Pathé workshops in Paris. The shops there employ over five hundred people in the manufacture of projecting machines, and the output is four hundred complete machines per week, the result of gradual growth from a beginning which dates back to the beginning of the industry. This data is here given to inform the reader that the Pathé Professional Model projector, which is a new machine to the American public and to the American branch of the motion-picture industry, is not an experiment.

Not the motion head alone, but every part of the entire machine is made in Paris. It is urged as an advantage that Europeans are very accurate and careful in building machinery; that owing to the very low price of labor more time can be given to the work of each machine; and that as a consequence the Pathé Professional Model projector is carefully and perfectly constructed. Against this, it is urged that the foreign manufacture is an objection to the Pathé machine, upon the assumption that in the case of a breakdown it would be hard to obtain repairs. Waving aside as biased the usual manufacturer's claim that the machine is incapable of breakdown, full weight still must be given to the fact that Pathé Frères carry a complete stock at their American factory at Bound Brook, New Jersey, and at their offices and supply stations in New York, Chicago, and San Francisco.

All this is not for the purpose of boosting the Pathé machine, but for the purpose of making the reader familiar with some facts of interest in connection with the motion-picture industry, and to brush away that prejudice which the patriotic American attaches to everything of foreign manufacture. The Pathé machine is one of the foremost in use in America today. In the early days, there was no sale for a machine of so high a price, but with the steady growth of the industry Pathé Frères began to push their machine and it found a wide market.

The complete Pathé outfit is shown in Fig. 83, the view being taken from the operator's side of the table.

The intermittent movement is a one-pin Geneva mechanism. The star wheel and pin cam are placed in a lubricating box to reduce friction and wear and also to reduce noise. The construction of the intermittent mechanism is calculated to give a ratio of six to one, that is, one-sixth motion and five-sixths rest for the total picture interval. This is with a view to giving a sharp picture free from flicker. When the light is not crowded to its limit, the Pathé projector is capable of very delightful projection, and the operator should set about getting it. With the stiff table legs and the floor "socles" as Pathé Frères prefer to call them, the machine can be made rigid. In connection with this, the manufacturers recommend an arc light using only twenty-five amperes.

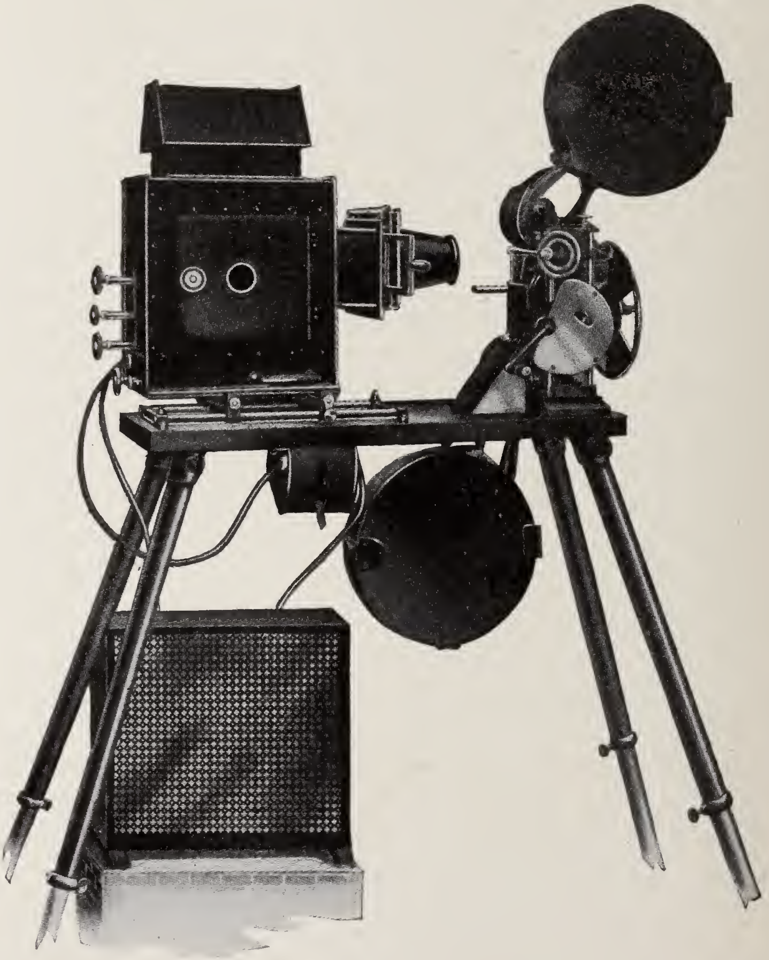


Fig. 83. Pathé Professional Outfit

The shutter is placed in front of the lens. It is a three-wing multiple-blade disk shutter, sixty degrees in each wing, the American standard shutter for all modern machines.

The film feed system is the American standard, triple sprocket system. The top sprocket runs continuously, feeding the film from the top magazine; the middle sprocket is intermittent, for stopping the film for exposure upon the picture screen; the lower sprocket runs steadily and feeds the film into the take-up reel in the lower magazine. The film does not touch the mechanism in any way in the center or picture strip of the film, but only in the edges where the perforations are placed, reducing as much as possible the pull or friction upon the film and the probability of scratching or damaging it.

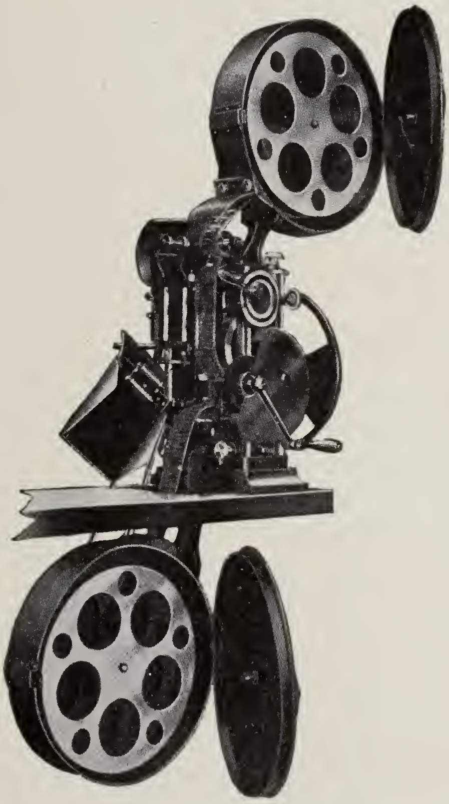


Fig. 84. Pathé Mechanism with Magazines (rear view) Open

The framing device is worked by a small lever which raises or lowers the picture, and which can if desired be locked in position by a thumb screw.

The automatic fire shutter holds the film window of the motion head normally closed; it is operated to lift out of the beam of light only after the motion head has begun to turn, and as soon as the speed is reduced for the purpose of stopping, the shutter again drops into position in the beam of light and protects the film in the window.

The flame shields protect the film from exposure to the light and heat of the lamp and lamp house from the time it leaves the upper magazine until it is wound into the lower magazine.

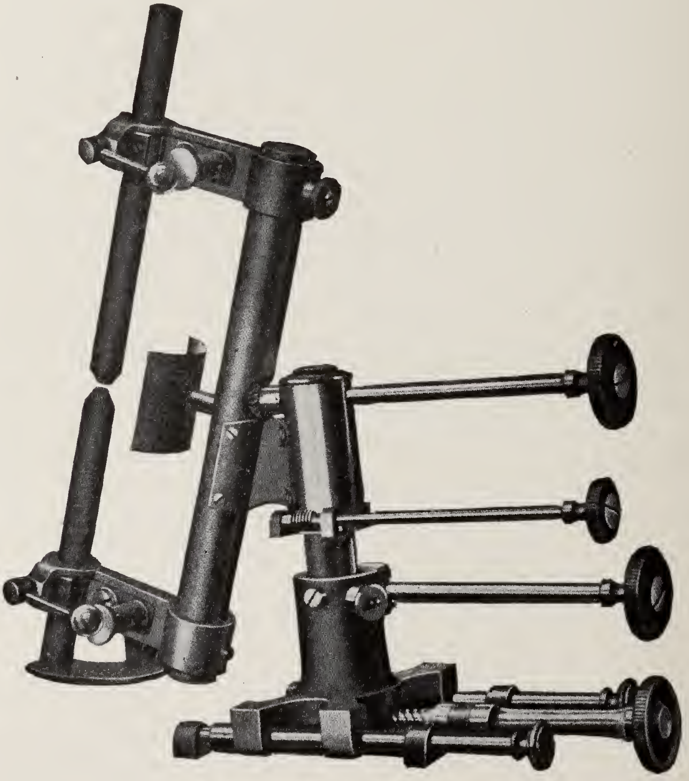


Fig. 85. Pathé Arc Lamps

The flame shields are hinged at the left, as are also the safety shutter and the film gate, so that all of the parts in front of the film as the operator views it, looking at the back of the motion head, may be swung out of the way for inspection, for cleaning up the path of the film, and for threading up the film through the motion head. Fig.

84 shows the motion head thus opened, showing also the magazines open and the position which the film assumes in its passage through the motion head.

The fireproof magazines (upper and lower) are round, with hinged doors, and roller film outlet and inlet. The film passes through between two rollers which are fitted together tightly enough to prevent flame from getting through into the magazine, yet are so constructed as not to scratch or injure the film as it passes between them.

The reels in the magazines are of steel, and are of the standard 10-inch size for 1,000 feet of film.

The lamp house is of large size. It has doors on both sides and a slide in the rear, in addition to which the top lifts off, enabling the operator to get at the lamp from all sides, and from the top. The lamp house is attached to the table by a system of adjustable sliding rods which permit a forward and backward movement, as well as a side movement to the position for the stereo lens when slides are to be projected.

The condenser glasses are placed in a cell which is so designed as to be taken out of its support easily when the lamp house is hot. The condenser glasses are of the standard American size, 4½ inches in diameter, and any condensers of this size used in any other projecting machines may be used in the Pathé Professional—it is not necessary to use an imported glass.

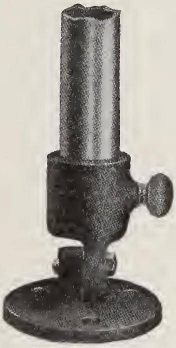


Fig. 86. Pathé Anti-Shake Socle

The slide carrier is of metal.

The arc lamp is made of heavy steel and bronze; the lamp itself, removed from the case, is illustrated in Fig. 85. By means of the top fiber knob, the operator is enabled to feed the carbons; by means of the next knob, the small one, the operator is enabled to shift his light from left to right or from right to left; by means of the large knob third from the top, the operator is enabled to raise or lower the light; and by means of the bottom knob he is enabled to move it forward or backward and still keep it under perfect control all of the time. The carbon holders are held in place by an automatic device which does away with the necessity of tightening them with a screw. This automatic device also prevents the carbons from falling because of the expansion of the metal parts holding the carbon when the lamp heats up. The angle or slope of the carbons is not adjustable.

The table is a wood top with adjustable legs. Each leg is two telescopic steel tubes, held together by a thumb screw. This is shown clearly in Fig. 83. By the adjustable legs, the table may be leveled, or may be tilted at any desired angle to get the best picture upon the screen possible from any enforced location of the projector. The legs may be attached rigidly to the floor, and the table shake may be eliminated by the use of a set of Pathé "socles," illustrated in Fig. 86.

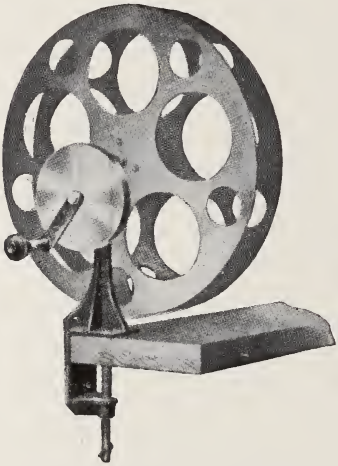


Fig. 87. Pathé Film Rewinder

Rewinding of the film reel is not done with the motion head but with a separate simple rewinder, illustrated in Fig. 87.

In Fig. 88, the repair parts most likely to be needed are illustrated and numbered, and a list of parts by name and number also is given.

To thread up the Pathé Professional, first open up both gates and both magazine doors, opening up the back of the motion head as is shown in Fig. 84. See that the framing lever, the small brass handle on the right side of the machine, is about in the center of its motion, that is, the lever should be approximately over the "h" of the word "Pathé" on the quadrant in which the framing lever turns.

Place the film reel in the upper magazine so that the film unwinds from the top. Next, pass the end of the film between the two magazine rollers in the film outlet which is found on the lower part of the magazine. Close the upper magazine door. Draw out about a foot of film and mesh it over the upper socket. Now place the film in the film track, first, however. making a loop interiorly in the film between the upper sprocket and the film track. Mesh the film over the intermittent sprocket, holding the loop in place with the right hand, and close the upper gate. Turn the shutter with the hand until the film moves down, then mesh the film over the lower sprocket, allowing for a loop as described above. The lower loop should be made just long enough to avoid touching the lower chain gear shaft. A turn of the operating handle now will draw film enough through the machine to enable the operator to pass it between the rollers at the film inlet of the lower magazine and from there to the reel hub, where it is fastened in the usual manner. Turn the reel by hand to tighten up any slack film and close the lower magazine door and the lower film gate and flame shield. Be sure that the groove in the lower reel fits snugly to the pin in the lower magazine spindle. Both the top and lower reels are designed to turn *counterclockwise* and on no account should the spring belt of the magazine be crossed to reverse the motion of the lower reel. The tightness of winding of the lower reel can be regulated by tightening or loosening the two milled nuts on the lower magazine spindle.

The manufacturers offer the following special suggestions for the care of the Pathé Professional:

> The fact that a machine is strongly built is no reason why it should be abused. All machinery requires lubrication, and a motion-picture machine is no exception to the rule.
>
> There are two oil cups on the shutter shaft. Two on the upper sprocket shaft and two on the lower. Three on the fly-wheel shaft and two on the intermittent sprocket shaft. One on the upper chain gear and one on the toothed gear on the right-hand side of the machine. There is also another spur-gear shaft on the right-hand side with two oil cups.
>
> The star wheel runs in oil and the lubrication case should be filled daily. The star wheel is the most important part of a motion-picture machine, as upon it the steadiness of the picture depends. The star wheel in the Pathé Professional machine is accurately adjusted at the factory and should not be meddled with.
>
> Only the best quality of machine oil should be used for lubricating the working parts.
>
> The film tracks and sprockets should be kept clean by being brushed occasionally with a clean tooth brush. The film tracks may be rubbed occasionally with a very small quantity of vaseline.
>
> The window frame is removable for cleaning purposes. It should not be cleaned with a knife or other sharp instrument, but should be rubbed with a clean stick of wood. A very small quantity of gasoline sometimes is useful in cleaning the film sprockets and tracks.

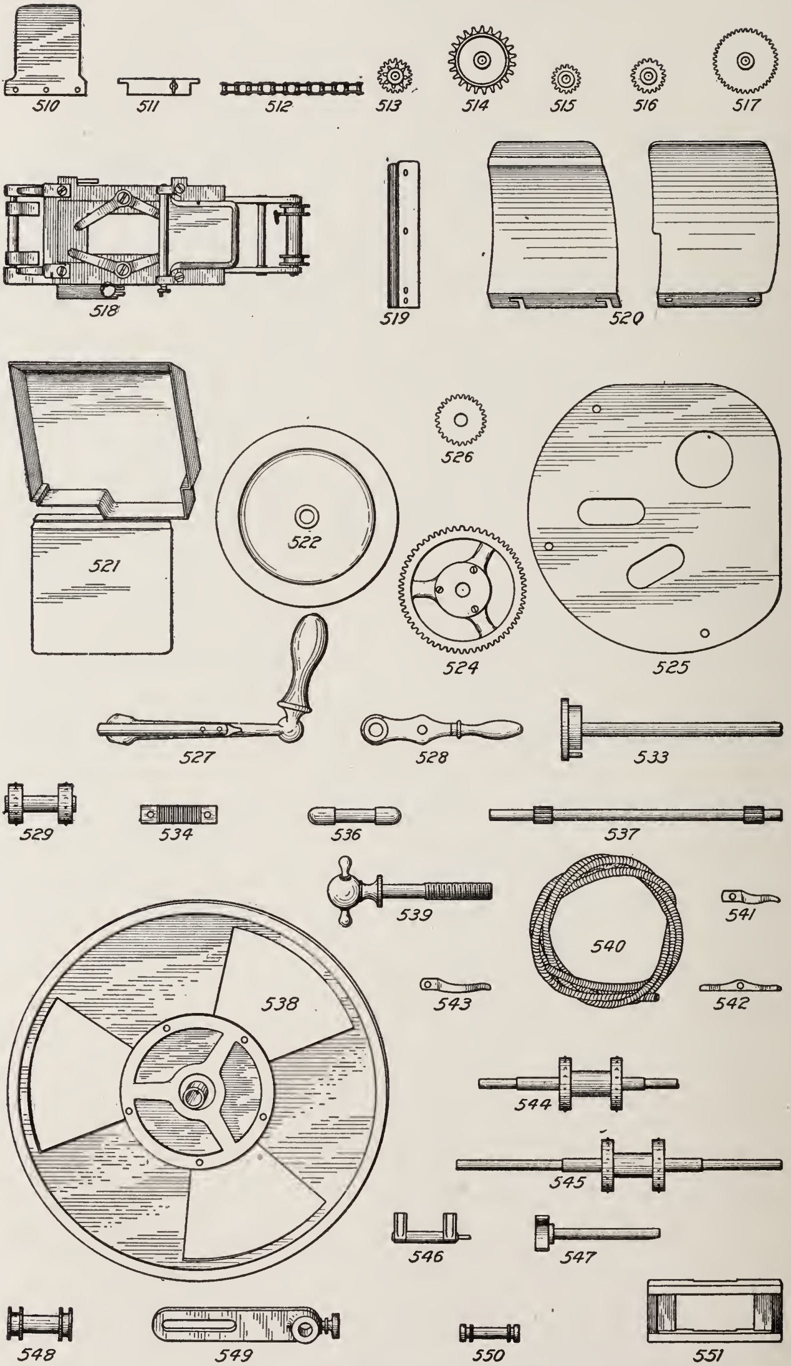


Fig. 88. Pathé Professional Model Parts

INDEX OF PARTS

501	Arc lamp
502	Asbestos-covered wire with terminal
503	Oak board
504	Lamp house, sliding base and cone
505	Legs and flanges, complete set
506	Mechanism head without reels, magazines or lenses
507	Rheostat
508	Slide carrier
509	Double pole switch and cover
510	Automatic shutter shield
511	Bolt
512	Chain
513	Upper chain cogwheel and gear
514	Lower chain cogwheel
515	Steel cog gear, 28 teeth
516	Steel cog gear, 35 teeth
517	Steel cog gear for take-up
518	Complete door with shutter
519	Steel film track
520	Upper flame shield
521	Lower flame shield
522	Fly wheel
523	Framing cog gear
524	Bronze gear, 112 teeth
525	Gear guard
526	Gear for shutter shaft
527	Handle
528	Handle for framing device
529	Intermittent steel sprocket
530	Upper magazine
531	Lower magazine
532	Milled screw
533	Steel pin wheel
534	Rack
535	Steel reel, 10-inch
536	Roller for magazines
537	Shaft and gear for framing
538	Shutter
539	Socket screw
540	Spring belt
541	Spring for tension holder
542	Spring for top of door
543	Spring for window frame
544	Upper sprocket with shaft
545	Lower sprocket with shaft
546	Steel sprocket tension holder
547	Steel star wheel
548	Upper steel roller
549	Stereopticon attachment
550	Steel tension roller for take-up
551	Steel window frame
552	Binding post
553	Carbon holder
554	Shaft with fiber knob and gear
555	Cone
556	Hood
557	Fiber knob for door
558	Red glass for door
559	Sliding base
560	Sliding rod, 15 inches
561	Sliding rod, with screw end, 16 inches
562	Condenser lens, bi-convex, 4½ inch diameter
563	Condenser lens, plano-convex, 4½ inch diameter
564	Condenser lens, meniscus, 4½ inch diameter
565	Condenser mount without lens
566	Motion picture jacket
567	Motion picture lens, any focal length
568	Stereopticon lens without mount any focal length
569	Stereopticon mount without lens

THE STANDARD PROJECTOR

The unique feature of the "Standard," or "American," projector is in the film protection. Other machines provide fireproof magazines and numerous devices for protecting the film from the heat of the lamp, while passing from the upper to the lower magazine, and still other shields for preventing the film from coming in contact with the lamp house when running out of the projecting head under the feed of the upper sprocket.

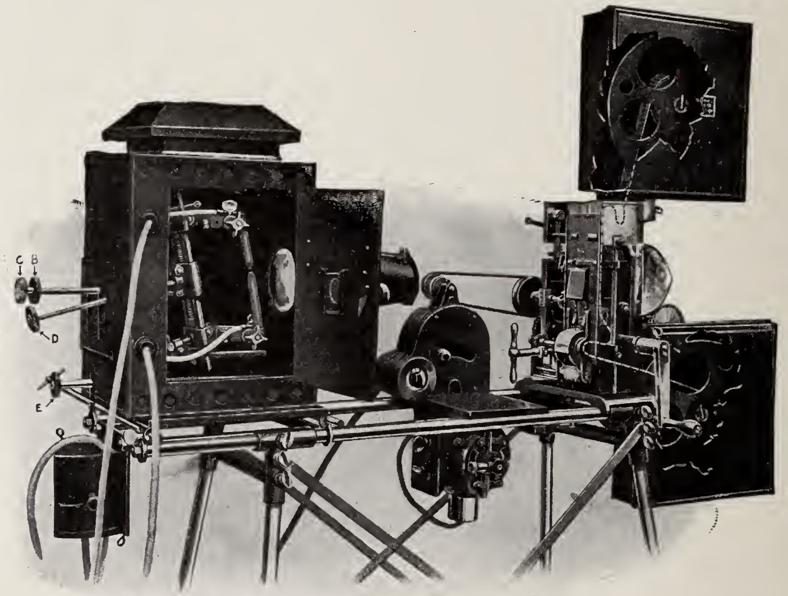


Fig. 89. No. 2 "Standard" Automatic Moving-Picture Machine with Motor

The "Standard" attacks this problem in a different way. A complete enclosed housing for the film is created, including the upper reel, the motion head, and the lower reel. The entire length of the film strip is protected and is completely enclosed, with the exception of the single image in the film window. The motion head is box-like in construction. The upper feed magazine is placed over the motion head and close upon it, leaving no space between in which the film can be exposed in passing from the feed magazine box to the motion-head box. The lower take-up magazine is placed just below the projection lens and against the front of the motion-head box, leaving again no space between where the film is exposed in passing from the motion head to the take-up magazine.

Because of the close fitting of the magazines to the box body of the projection head, no film-friction film outlets are used upon the magazines, either upper or lower, a flame trap being built into the box-like motion-head frame.

The close construction of the three parts, upper magazine, motion head, and lower magazine, and the full protection of the strip of film, is shown clearly in Fig. 89, giving a general view of the "Standard" projection equipment. Not only are the motion head and magazines shown, but also the "Standard" table, built wholly of metal rods and tubes, the lamp house, and the motor. The showing of the motor in the picture recalls the fact that at one time the "Standard" was the only projection machine which was permitted to run by motor in New York, all others being compelled to turn by hand. The feature of distinction upon which this discrimination was based was that the film could not be fed by the motor and upper sprocket to make contact with the lamp house or to fall into the beam of light outside of the motion head, because of the enclosed box construction of the entire film-handling mechanism and magazines.

The "Standard" does not use the opaque shutter, but uses a semi-opaque or translucent shutter which gives a soft haze to the picture screen during the short interval of shift of the film. By changing the interval of darkness into an interval of haze, the flicker is reduced; and the claim is made also that an equal screen illumination is produced with a smaller current consumption in the lamp. This, however, lies with the operator; the rule of *less light and smoother picture* or *more light and more flicker* is a fundamental principle in the optics of the motion-picture system when projection by persistence of vision is practiced, and it applies to the "Standard" machine along with the others. There is room for the exercise of the operator's skill with all of them in the matter of flicker.

The operator must discriminate between "flicker," which is the variation of the intensity of the light by which the screen seems to wink at the spectator, and "jiggle," which is the dancing about of the fixed objects of the projected picture, due either to faulty intermittent mechanism or film gate adjustment, or to an unsteady table which yields to the force applied to the crank handle.

The single image of the film which is in the film window is

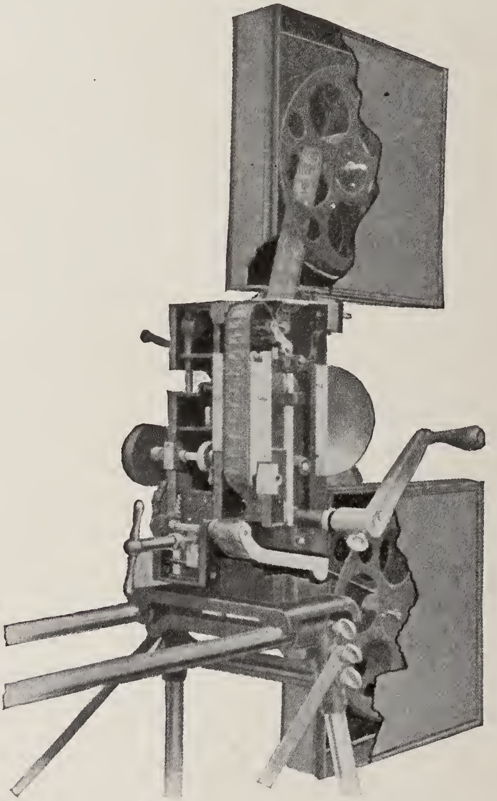
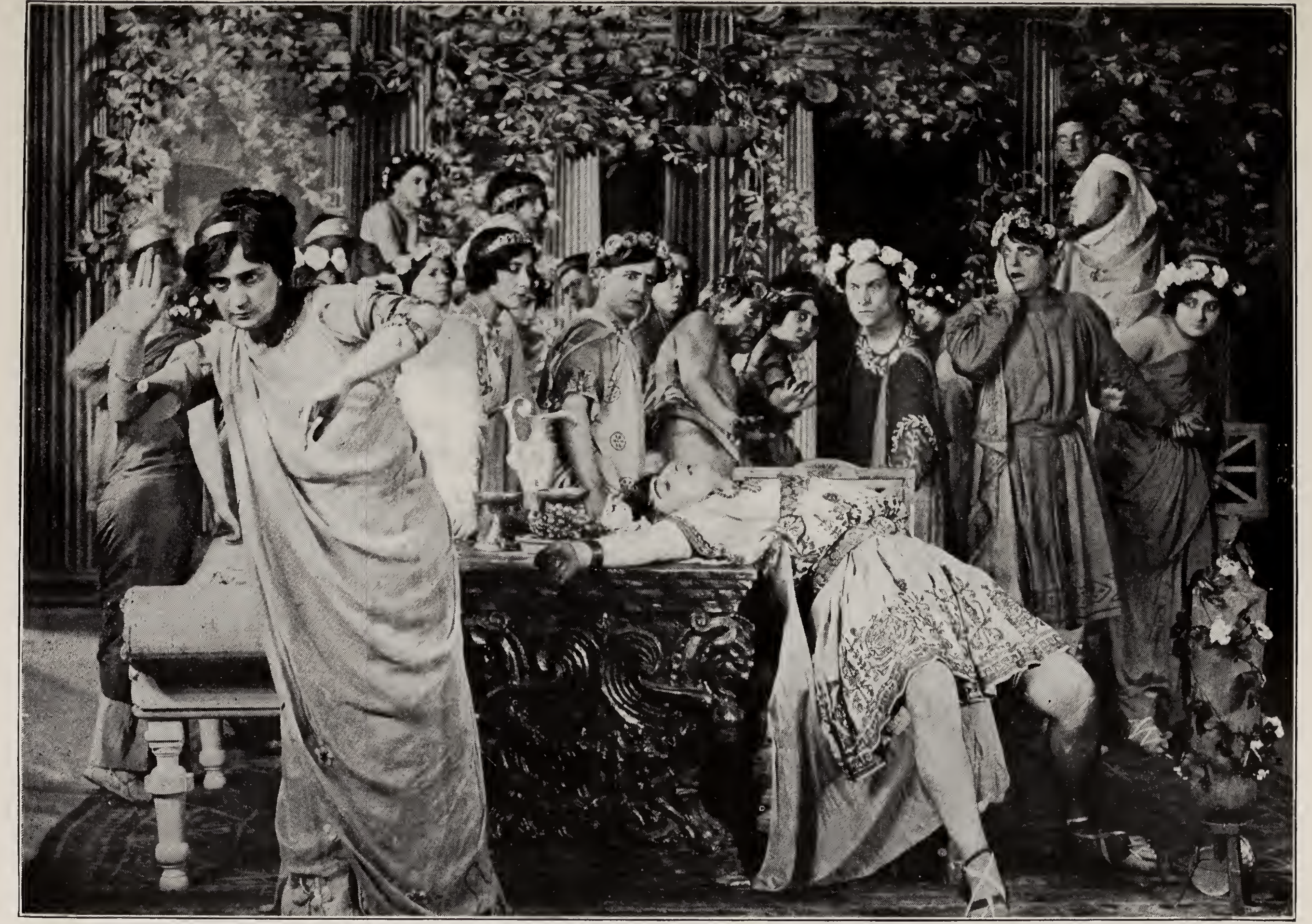


Fig. 90. "Standard" Motion Head

guarded from the heat of the lamp by a hinged shutter which falls over the window when the driving mechanism of the machine is not in motion. When the motion head is being driven at projecting speed, a speed governor acts to engage and lift the safety shutter from the film window, and to hold it up as long as the speed of the motion head continues, dropping it before the window as soon as the motion stops.



SCENE FROM "THE DAYS OF NERO," BY GAUMONT

Probably the Greatest Portrayal of This Time in History, That Has Ever Been Given the American Public
Courtesy of the *Kleine Optical Co., Chicago*

The intermittent movement of the film is obtained by the usual arrangement of Geneva mechanism. The Geneva pin wheel is so built that when the pin becomes worn a new one may be installed to replace the worn one.

The lamp house is adjustable toward or from the motion head by sliding its cross track directly upon the two metal tubular rails which form the top bars of the operating table or frame. The cross track is a pair of parallel bars to permit the lamp house to be slid over for the stereo lens of the motion head as required.

The construction of the motion head and the course of the film through it is shown in greater detail in Fig. 90, where the side of the motion-head box and the film gate door and back plate or "back door" of the motion head are removed to reveal the mechanism.

The principal parts of the "Standard" machine which are likely to be required for repairs are shown in Fig. 91 with their identification numbers; in addition, a list of the parts by name is given with their numbers.

The lamp of the "Standard" machine removed from the lamp house in order to reveal all of its parts, is shown in Fig. 92. The knob *D* feeds the carbons. The knob *B* for tilting the lamp and the knob *C* for raising and lowering it are together, the knob *C* being upon a rod and the knob *B* being upon a tube which is sleeved over the rod. This distinction of a double knob as compared with a single knob will help the operator to avoid the error of turning the wrong knob and throwing his screen lighting out of adjustment when, with his eyes on the screen and his right hand turning the crank, he reaches with his left hand to feed the carbons. If, under such circumstances his hand touches the double knob, he will not turn it by mistake. The knob *E* moves the lamp toward or from the condensers.

The adjustment of the angle of the carbons with respect to each other is attained only through the door of the lamp house, by turning the knob *G* for the lower carbon, or *H* for the upper carbon. By these knobs, the carbon holders may be set for direct-current or alternating-current positions, the difference in alignment between the centers of the upper and the lower carbons of the direct-current setting also being controlled by the knobs *G* and *H*. Knobs *A* and *F* are lock knobs for the carbon pencils in the holders.

INDEX OF PARTS

1 Star wheel and spindle (one piece)
2 Bushing on intermittent spindle (short)

7 Collar
8 Gear
9 Bronze bearing
10 Collar
On fly wheel spindle

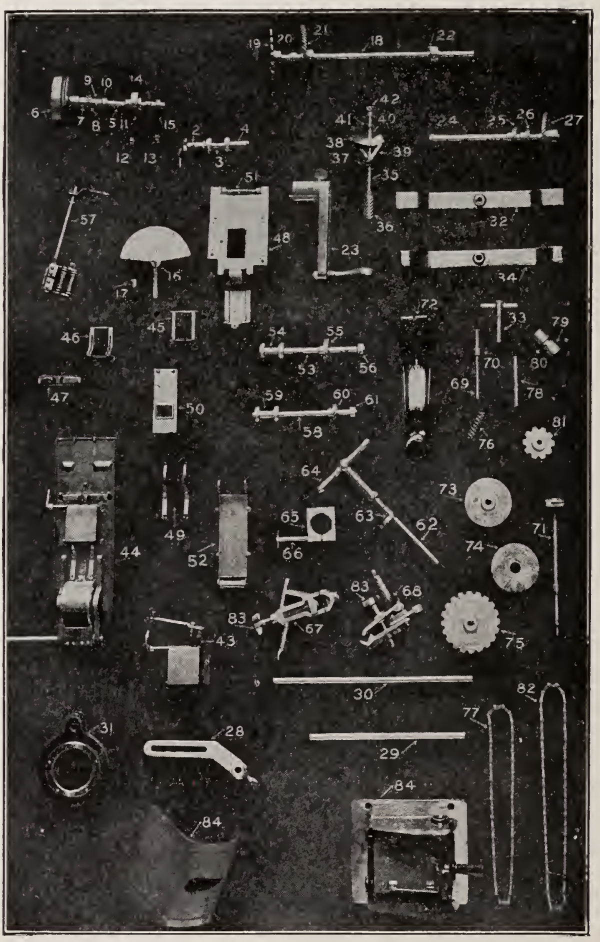


Fig. 91. Repair Parts for "Standard" Projector

3 Intermittent sprocket
4 Bushing on intermittent spindle
5 Fly wheel spindle
6 Fly wheel

11 Pin wheel
12 Engaging pin for pin wheel
13 Screw to hold pin in pin wheel (hardened)

14	Bronze bearing for fly wheel spindle	
15	Gear connecting with shutter gear	
16	Revolving shutter and spindle	
17	Revolving shutter gear	
18	Driving shaft spindle	
19	Chain sprocket	On driving shaft
20	Collar	
21	Spiral gear	
22	Clutch collar	
23	Handle for driving (complete)	
24	Transmission spindle	
25	Gear 42 teeth	On transmission spindle
26	" 12 "	
27	" 15 "	
28	Stereopticon bracket	
29	Stereopticon bar, short	
30	Stereoption bar, long	
31	Stereopticon ring casting	
32	Mechanism fastening casting	
33	Screw for mechanism fastening casting	
34	Motor fastening casting	
35	Governor spindle	
36	Sliding gear on governor	
37	Governor head	
38	Governor wings (each)	
39	Governor arms (each)	
40	Governor pin	
41	Governor collar	
42	Gear on governor spindle (8 teeth)	
43	Fire shutter (complete)	
44	Door for machine (complete)	
45	Aperture tension cradle	
46	Film tension guide (intermittent sprocket)	
47	Door lock (complete)	
48	Film slide and cradle (complete)	
49	Springs for aperture tension cradle (each)	
50	Aperture plate	
51	Guiding spool for film track (complete)	
52	Film shute	
53	Upper film sprocket spindle	
54	Upper film sprocket	
55	Gear	On upper film sprocket spindle
56	Collar	
57	Upper idler roller lever (complete)	
58	Lower film sprocket spindle	
59	Lower film sprocket	
60	Gear	On lower film sprocket spindle
61	Collar	
62	Framing device spindle	
63	Framing device eccentric	
64	Framing device handle	
65	Framing device sliding box	
66	Screw adjustment for sliding box	
67	Carbon holder for A. C. (each)	
68	Carbon holder for D. C. (each)	
69	Reel spindle (upper magazine)	
70	Collar on reel spindle (upper magazine)	
71	Reel spindle with collar and lock nut (lower)	
72	Take-up bracket with tightening nut	
73	Friction plate on lower reel spindle	
74	Friction washer	
75	Large chain sprocket on take-up	
76	Spring on take-up	
77	Chain on take-up	
78	Spindle for eccentric on take-up	
79	Eccentric bushing on take-up	
80	Set screw for eccentric on take-up	
81	Small chain sprocket on take-up	
82	Chain (take-up to mechanism)	
83	Carbon holder tightening screw	
84	Switch and switch box with nickel base	

To thread the film through the motion head, slide the full feed reel over the spindle in the upper magazine. Open the back door of the motion-head box. Pass the end of the film between the two flame-trap rollers on the top plate of the motion-head box near the upper sprocket; then under the upper sprocket; let the pair of clamp rollers rest upon the film, holding it against the upper sprocket. Turn the framing lever "up" as far as it will go, to make the upper feed loop as large as possible; then turn the fly wheel by hand until the intermittent sprocket just starts, then make an upper feed loop so that it will come ½ inch under the top plate of the motion-head box; pass the film down the guides and over the teeth of the intermittent; make a small loop to lower sprocket and close the door. The film passes through the lower chute to take-up magazine and is attached to the hub there in the usual manner. Take up the slack by turning the take-up reel by hand, and give a half turn of the driving crank to see that the film is being taken up properly before

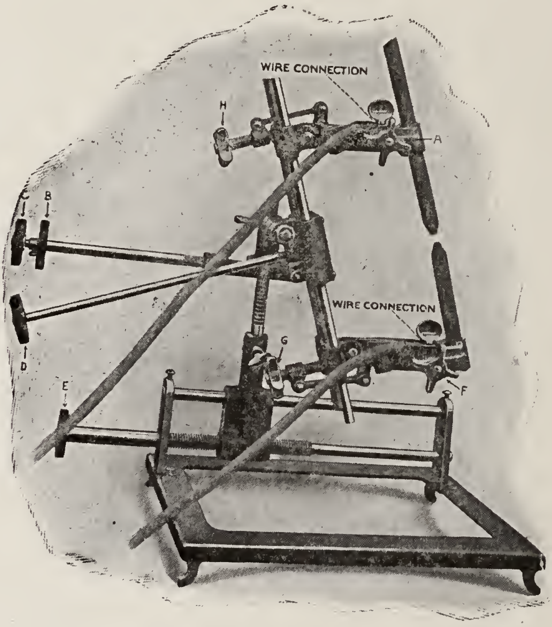


Fig. 92. Electric-Arc Lamp for "Standard" Projector

closing the door of the lower magazine. The precaution in forming the upper loop is necessary for the reasons that (*1*) if the upper loop is formed with the frame lever "down" by which the size of the upper loop may be increased when the frame lever is thrown "up," then the upper loop when thus increased may let the film rub against the inside of the top of the motion-head box; and (*2*) if the upper loop is formed as large as possible when the intermittent has just finished its pull, the upper steady feed will feed a full picture, or $\frac{3}{4}$ inch of film, into the upper loop before the intermittent pulls again, thereby increasing the size of the upper feed loop and perhaps permitting the film to rub against the inside surface of the motion-head box.

The take-up device is adjusted by a lock nut attached to the spindle of the lower magazine box. To adjust the tension, loosen the small screw in the lock nut. A turn then to the right will give more tension, and a turn to the left will give less tension. When the tension is readjusted to suit, tighten the small set screw in the lock nut again to hold the adjustment.

When the star wheel becomes worn or loosened, it can be adjusted to the pin wheel by loosening the four screws which hold the bronze bearings in place. To tighten the star wheel to the pin wheel, give both bronze bearings a slight but equal turn upward and again fasten the four set screws which hold the bearings fixed as adjusted.

The mechanism should be oiled thoroughly before beginning each afternoon or evening run. Do not forget to oil the leather washer between the flange and the large chain sprocket. Oil the spindle from an oil hole inside the box.

THE REWINDING "STANDARD" PROJECTOR

This projector is shown in Fig. 93. The take-up reel is in the square box below and in front of the motion-head box, while the feed reel, instead of being mounted edgewise above the motion-head box, is mounted flat.

The operation of this machine, which is classed as an "automatic rewinding projector," is not that it automatically rewinds the film, nor that it rewinds it at all, but that it uses the film for a second and third projection, and as many projections as required, without rewinding it at all. The top magazine, or feed magazine feeds from the middle of the reel.

Film reels received from the film exchanges usually are wound with the title end outside. When so received, the reel must be rewound before it is placed in the feed magazine of this "Automatic Rewinder" machine; and indeed, when the film is received with its leader inside the roll, as this machine requires it, the film must be rewound twice, to get it into a roll with a large opening in the middle. Having reeled the film up with a large center opening, and with the leader and title inside of the roll, the roll is dropped into the horizontal round feed magazine, the leader end is taken in the middle of the roll and is passed down through the floor of the feed magazine into the film inlet of the motion-head box, passing over the guides provided; the motion-head mechanism then is threaded with care for the upper and lower loop size, as described for the "Standard" machine, Fig. 90, and the leader end is taken into the take-up magazine and attached to the take-up reel, which has a large arbor, so that the film is rewound with a large opening in the middle.

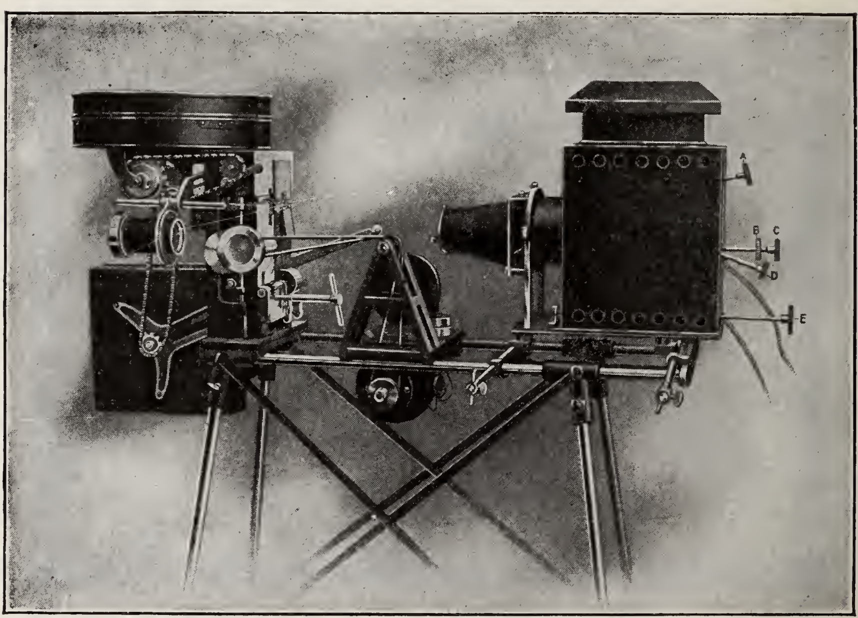


Fig. 93. The Rewinding "Standard" Projector

Projection is made by crank or motor, the strip of film feeding from the center of the feed magazine and winding up, head in, upon the take-up device.

When the strip of film has been completed, the operator lets the tailpiece run through until it is completely wound upon the take-up reel. He then opens both the take-up magazine and the empty feed magazine, takes the film off of the take-up device without the reel, and places the film without the reel in the feed magazine, starts the inside end of the film down through the floor of the feed magazine and over the guides, threads up the motion-head mechanism, attaches the leader to the take-up mechanism, closes up the doors, and is ready for projection again, repeating as often as his program requires. When a program of two or three reels is being run, one reel after another, the old reel is lifted from the take-up device and placed flat in a metal storage box, placed upon the shelf flat to keep the open roll or hank of film from collapsing, and the new hank is dropped into the feed magazine. No rewinding ever is required except to get the film into proper form for the feed magazine when it is received from the film exchange or factory, and to wind it up again upon a small arbor to pack it in the small shipping box in which it was received from the exchange.

This machine is no longer offered for sale by the manufacturers, and theaters equipped with them may have the special magazines replaced with the later type, requiring rewinding, if the automatic rewinding feature is not entirely satisfactory.

THE SELIG POLYSCOPE

The old style Polyscope, made by the Selig Company, has been withdrawn from the market. It used the pin-shift mechanism controlled by two cams on the main driving shaft.

The Polyscope projector now sold by the Selig Company is illustrated complete in Fig. 94, and its motion head is shown in closer detail in Fig. 95, the door of the film gate being opened.

The film feeding mechanism is the American standard, three-sprocket, with Geneva intermittent drive.

In threading up the film, the feed reel is placed in the magazine on the top of the motion head, the end of the film is taken through the film outlet rollers, and the door of the feed magazine is closed.

By finger pressure upon a projecting lug, the presser roller is lifted from the upper constant feed sprocket until the film is placed upon the sprocket and meshed with the teeth.

The frame lever is now framed "down" to take out any slack which might be above the film gate, the film is placed in the track of the film gate with a slight slack above—at least one picture length—then meshed with the intermittent sprocket, and the film-gate door is closed. This causes the guide roller at the top of the door to engage the edges of the film, and presses the presser roller against the intermittent sprocket, both of these rollers being carried by the door. This step in threading might seem at first to require three hands on the operator, but the trick is to hold the end of the film below the intermittent with the left hand, to press the film above the motion-head frame with the long finger of the right hand and stretch it tight over the film window and along the film track of the gate, then

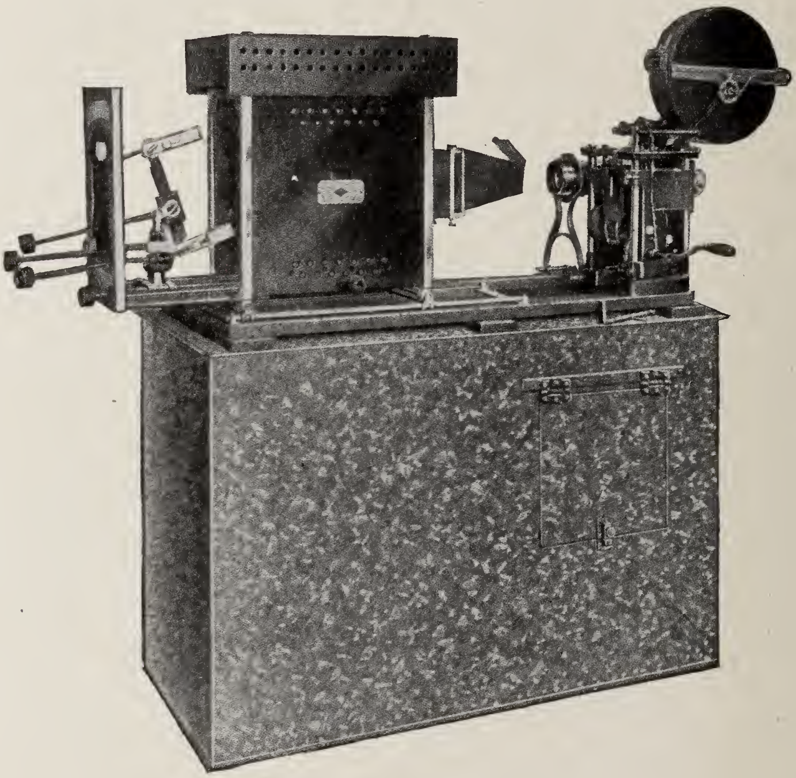


Fig. 94. Selig Polyscope Projector

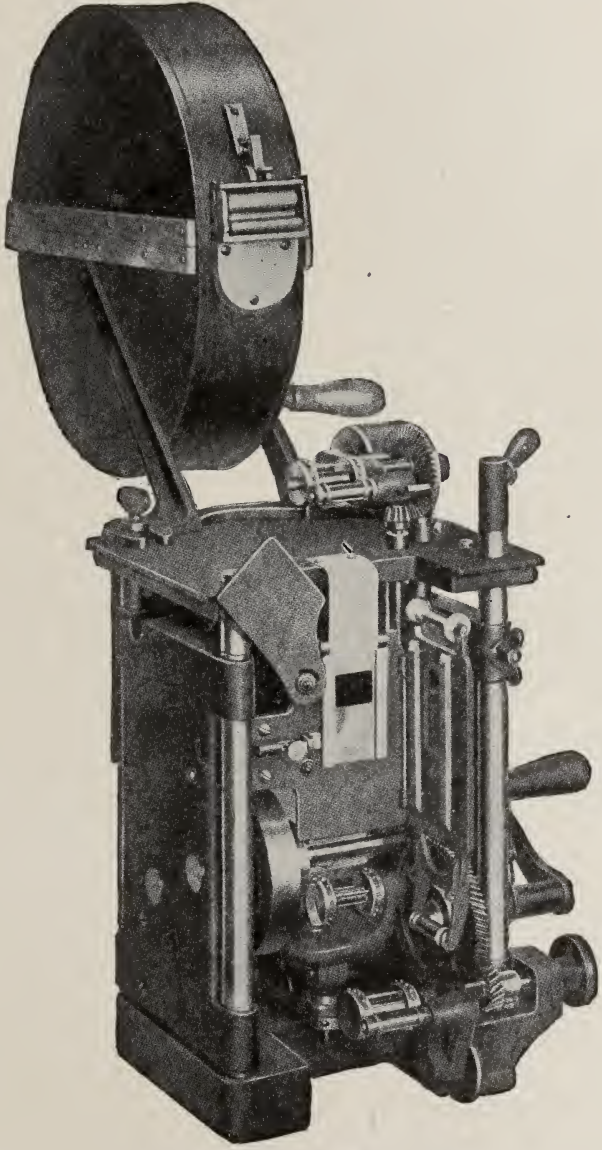


Fig. 95. Selig Polyscope Motion Head

to swing the door shut with the thumb of the right hand, which will be almost engaging the top guide roller of the gate.

Now frame "up" and give a little slack in the lower feed loop, then pass the film down into the magazine box, or to the take-up reel if one is used.

The Selig lamp house has the feature of sliding the lamp entirely out of the house to make inside adjustments, and to set the carbons. Fig. 94 shows the lamp withdrawn from the lamp house. Before projection is begun, the lamp is pushed in until the vertical panel at the back of the lamp closes with the body of the lamp house and forms a closed house. The controlling knobs have universal joints, permitting them to pass through very small holes in the back panel of the lamp house, and yet reach and operate their different parts of the lamp in any position of adjustment.

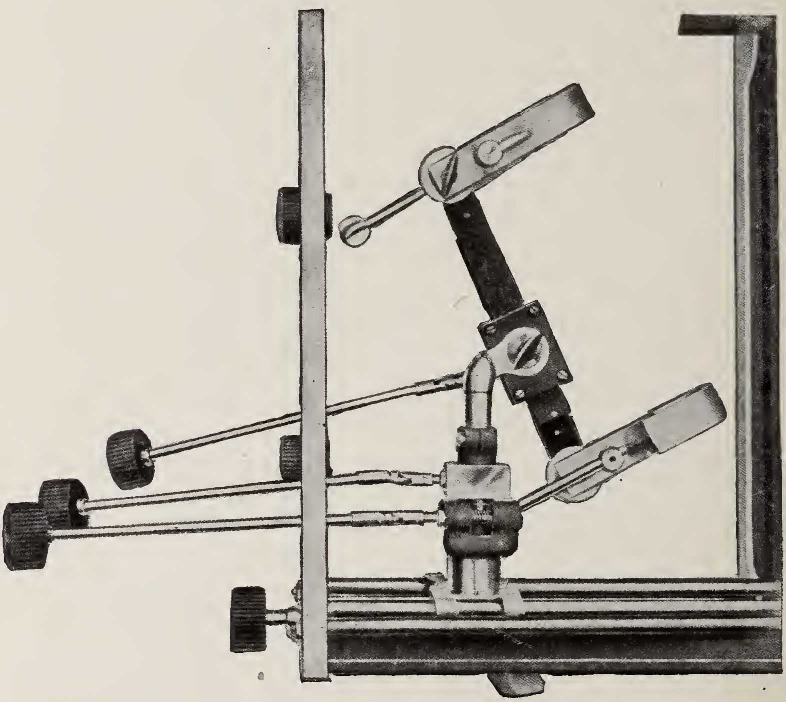


Fig. 96. The Selig Lamp

Four knobs are provided outside the lamp house, for lateral, transverse, vertical, and feed movements of the lamp. The angle of the carbons, either jointly for direct current or separately for alternating current, is adjusted by drawing the lamp from the house and working upon adjustments normally inside of the lamp house.

The Selig lamp is illustrated in detail in Fig. 96.

THE EDENGRAPH PROJECTOR

In the general design of this machine, the manufacturer has planned for the most direct film path possible, and for the separation of the film path from all entangling mechanisms as far as it is possible to do so. The path of the film is "in the open air" as completely as it is possible to make it, from the outlet of the feed magazine to the inlet of the take-up magazine. Fig. 97 shows the Edengraph in general view.

In Fig. 98 a close view of the motion head and magazines of the Edengraph are given, from which also the threading of the machine may be seen clearly.

After placing the feed reel in the upper magazine, the leading end of the film may be inserted into the outlet valve by slipping it through the slot in the side of the valve; it will then be properly placed between the two pairs of rollers, for there are four rollers in each of the film valves. The film is now carried around the upper sprocket, which is as close as can be to the upper film outlet, and is pressed to the upper sprocket by the single presser roller. The film is then taken over the flanged guide roller at the top of the film gate, the film gate is opened, and the film is carried down the film track to the intermittent, leaving a sufficient slack at the top of the gate for the top feed loop; the gate then is closed. The film is now brought around the lower sprocket and taken into the take-up magazine through another four-roller film valve and attached to the take-up reel in the usual manner. A turn of the crank will show that the take-up and feed elements are working properly, when all doors may be closed and the machine is ready for projection.

The film is rewound by a separate rewinder.

The gears of the motion head are all contained within the box-like frame, but are accessible by taking off the side of the box next to the stereo lens, first swinging the stereo lens out of the way, as shown in Fig. 99.

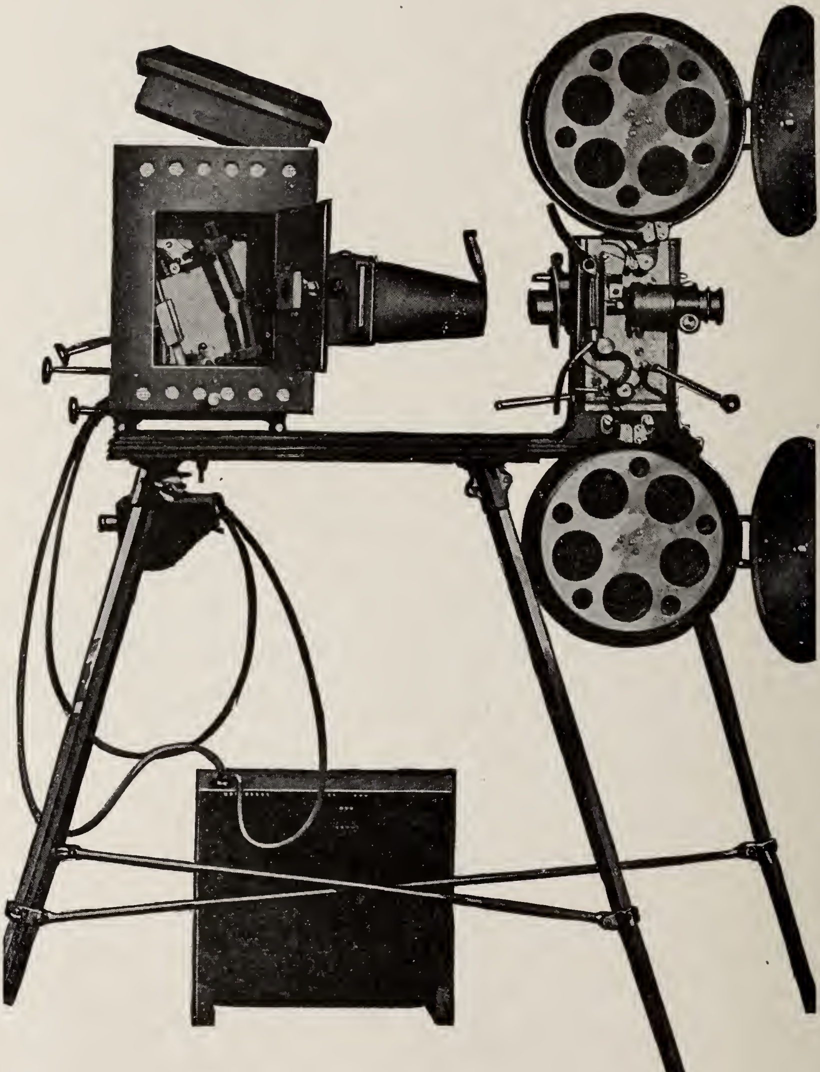


Fig. 97. The Edengraph Projector

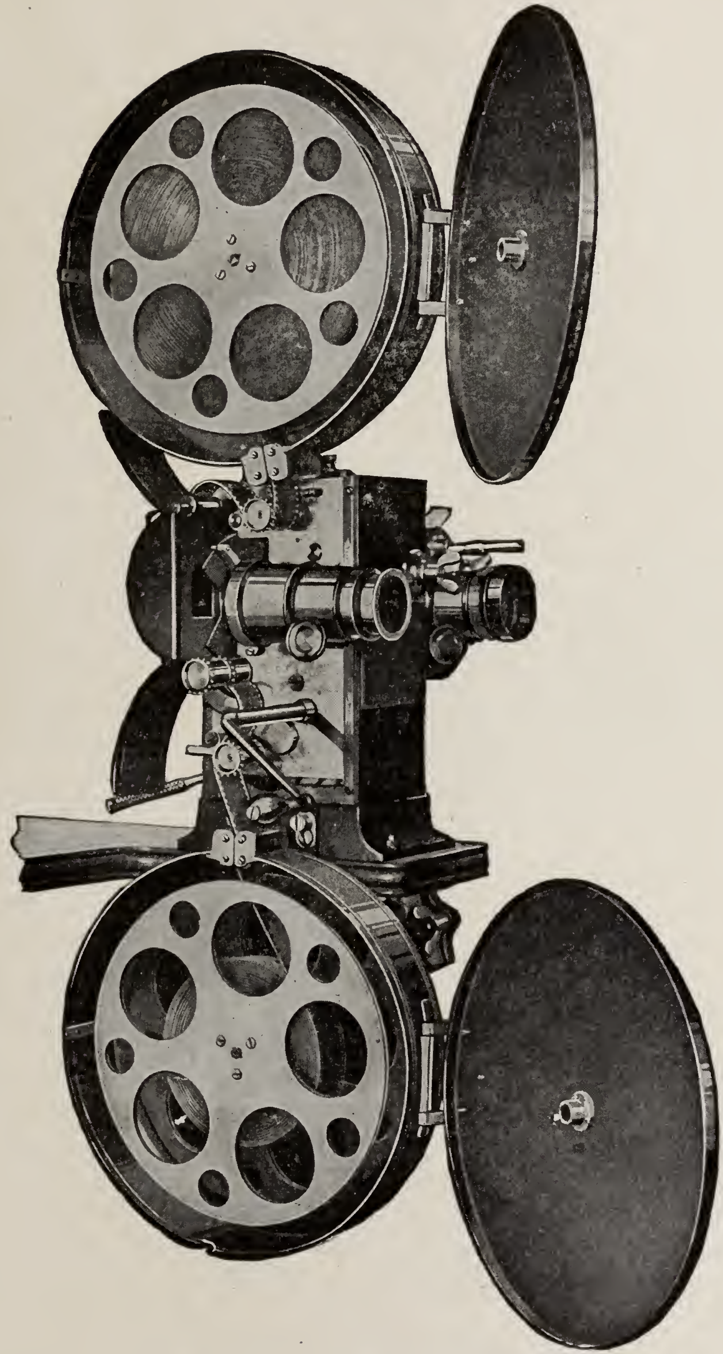


Fig. 98. Detail View of the Edengraph Motion Head

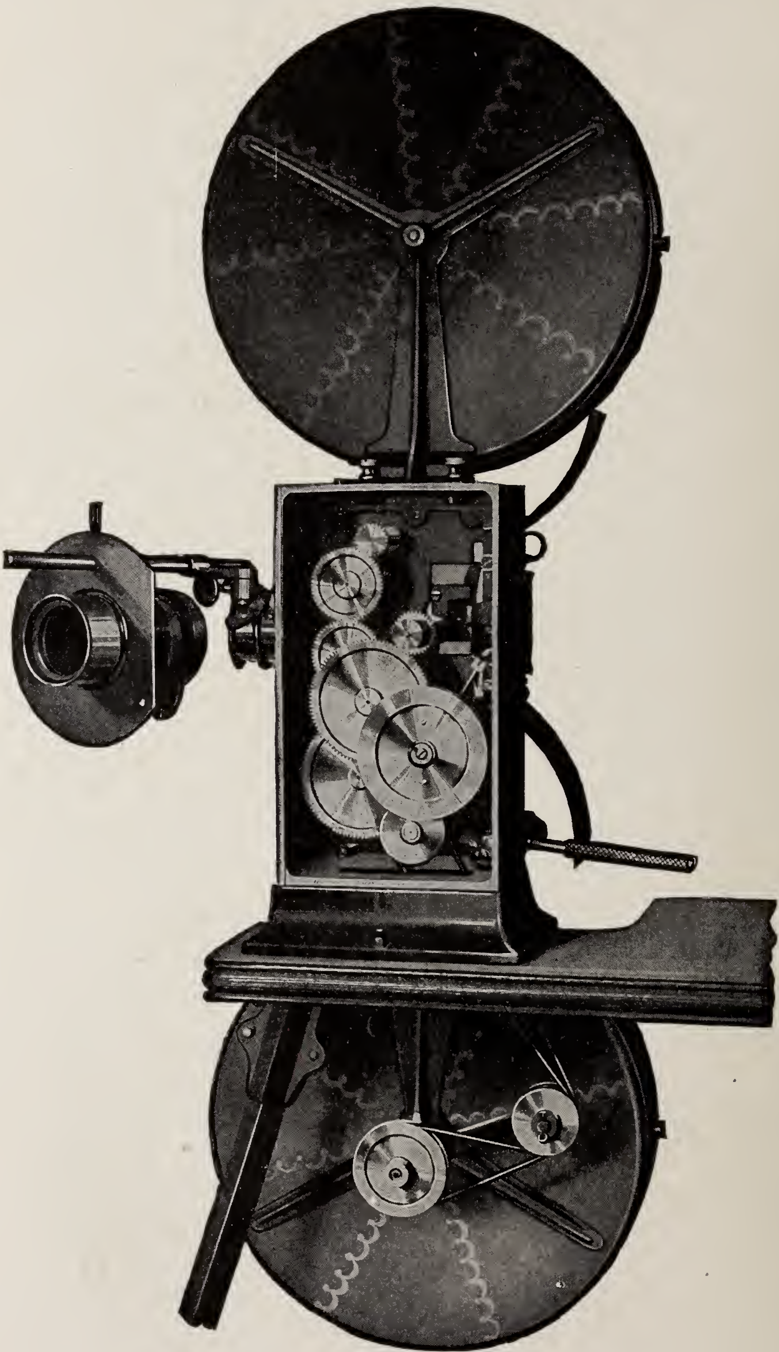


Fig. 99. Edengraph Gear Case of Motion Head

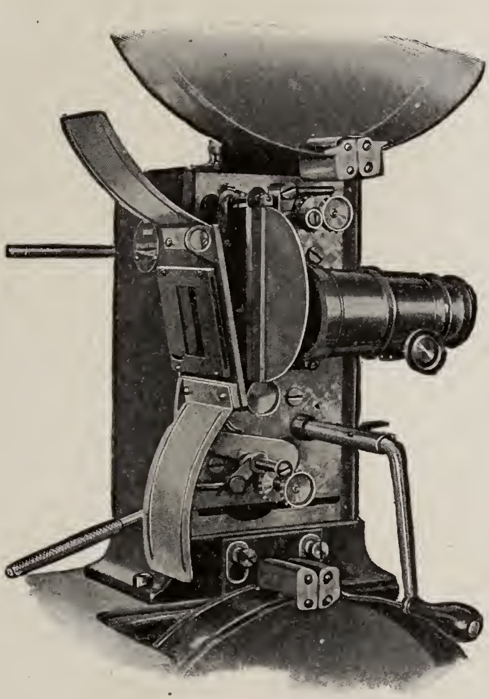


Fig. 100. The Edengraph Motion-Picture Mechanism with the Film Gate Swung Open on Its Hinge

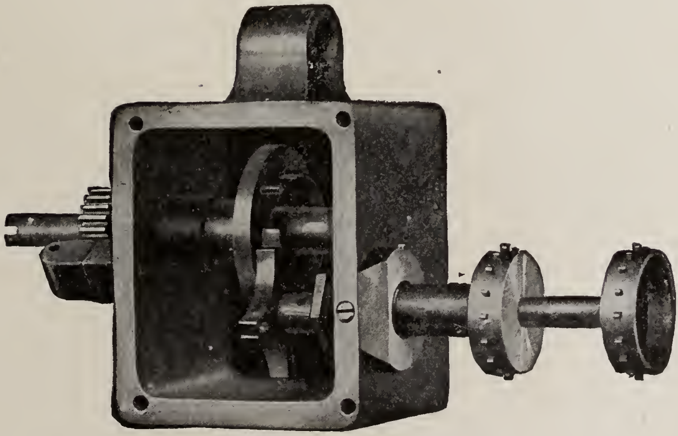


Fig. 101. The Edengraph Geneva Box

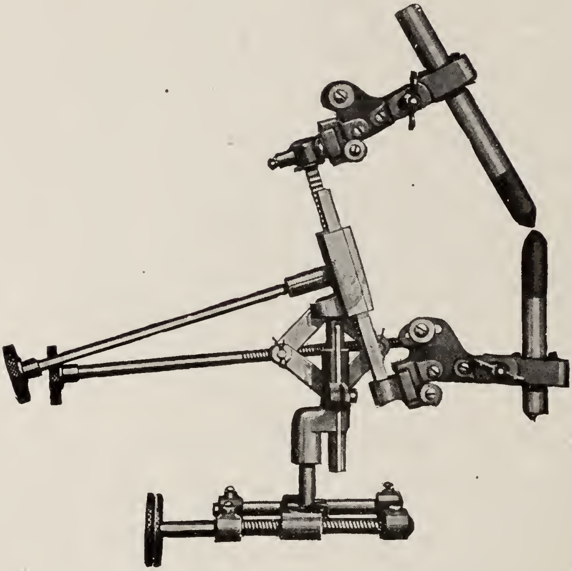


Fig. 102. The Edengraph Lamp Adjusted for Alternating Current

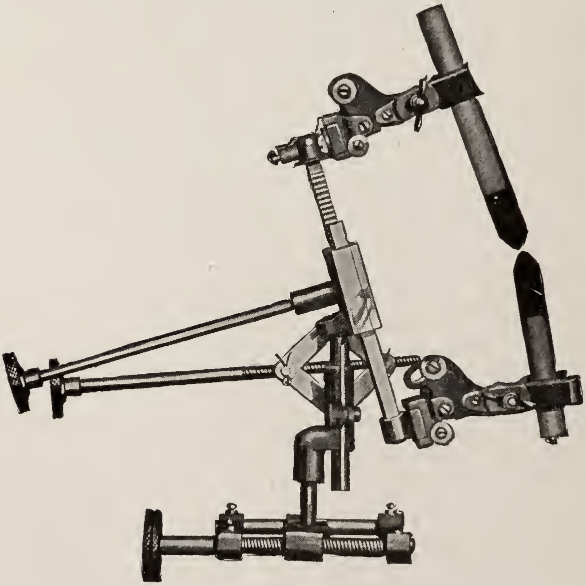
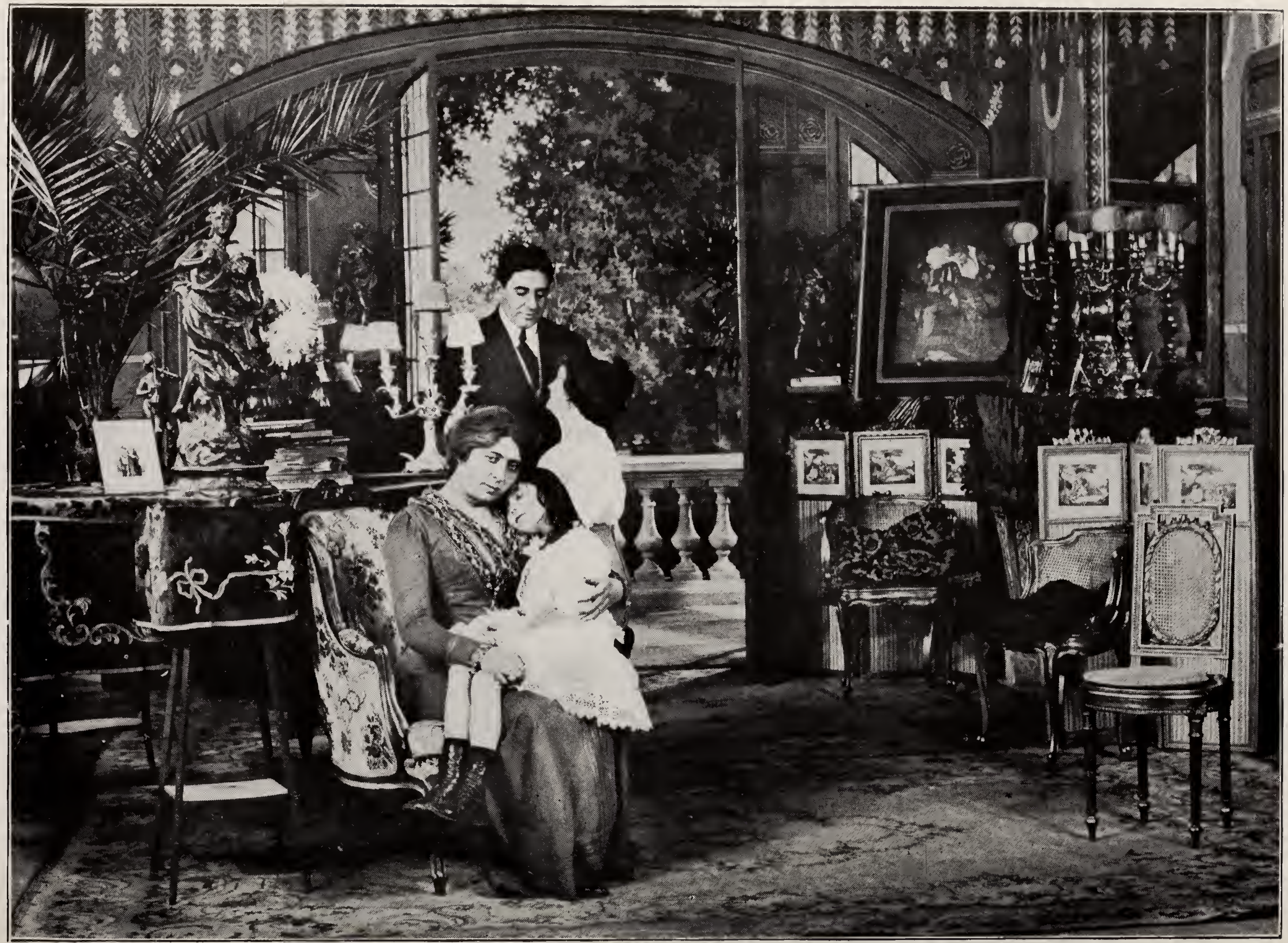


Fig. 103. The Edengraph Lamp Adjusted for Direct Current



SCENE FROM "LOST YEARS," BY GAUMONT

Illustrating the Remarkable Type of Motography Evidenced in the Modern Photoplay
Courtesy of the *Kleine Optical Co., Chicago*

The film gate door of the Edengraph is pivoted at the bottom, instead of at the side as is customary; the argument is that the pressure upon both edges of the film will be equal with this method of construction. The two fire shields are attached to the film gate door for the protection of the upper and lower feed loops. This detail is shown in Fig. 100.

The intermittent drive is the Geneva type of mechanism, enclosed in an oil box, the intermittent shaft projecting through the wall to pass outside of the motion-head frame to the film gate, Fig. 101.

The Edengraph lamp has three control knobs, the diagonal knob being carbon feed, the upper level rod being the adjustment for height, and the bottom knob being the adjustment for distance from the condensers. The adjustment for angle and the adjustment to the right or left is made inside the lamp house. Two views of the Edengraph lamp are given in Figs. 102 and 103, the lamp in Fig. 102 being shown adjusted for alternating-current arc and the one in Fig. 103 for direct-current arc.

THE LUBIN PROJECTOR

Lubin's "Marvel" is shown in general view in Fig. 104. A near view of the motion head, with the film gate door open, is shown in Fig. 105. In this device, the flame shield is pivoted to the operating table below, and attached to the gate door above.

The safety shutter is operated by a friction clutch, which must be kept clean and free from oil.

To set up the machine, the motion head is fastened to the table by means of the thumb screw which also holds the front leg of the table. The belt from the motion head to the lower magazine take-up shaft is crossed to turn the shaft in the proper direction.

The automatic fire shield must stand so that if the lamp house is in line with the mechanism the fire shield stands straight between the two. Hook the fire shield to the lamp house by means of the adjustable rod. When in proper position, the fire shield must almost touch the table.

Slide the electric lamp and the stand provided for it into the lamp house and fasten by means of the shortest handle, which also serves to raise or lower the lamp.

The condensers are placed in the holder with the round sides facing each other.

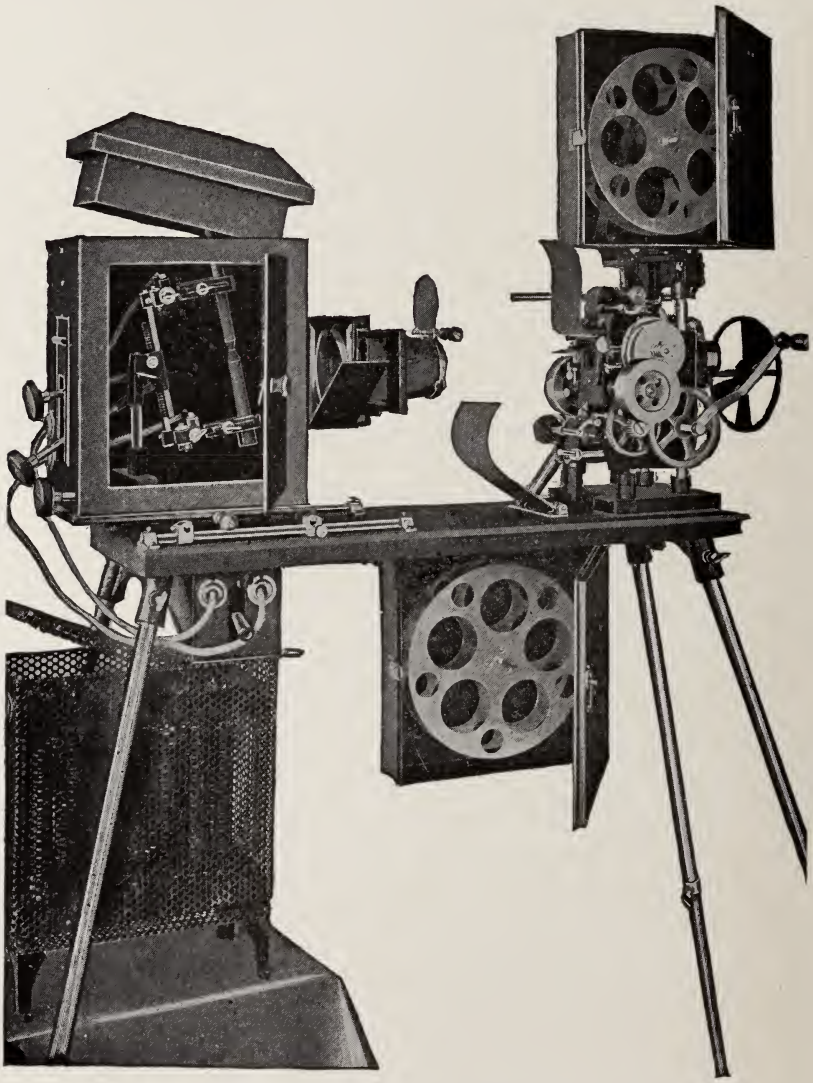


Fig. 104. General View of the Lubin Projector

To thread the film, push the lamp house to the left. This opens the fire shield and leaves the motion-head mechanism free. Place the full feed reel in the upper magazine. The film must unwind toward the left, and the emulsion or dull side of the film must be toward the lamp house, the figures, of course, being upside down, or heads down, and the leader or title being on the outside end of the reel. Pull the film through the rollers of the flame-trap or film outlet attached to the lower part of the magazine. Close the door of the magazine and fasten with the catch. Bring the film to the top

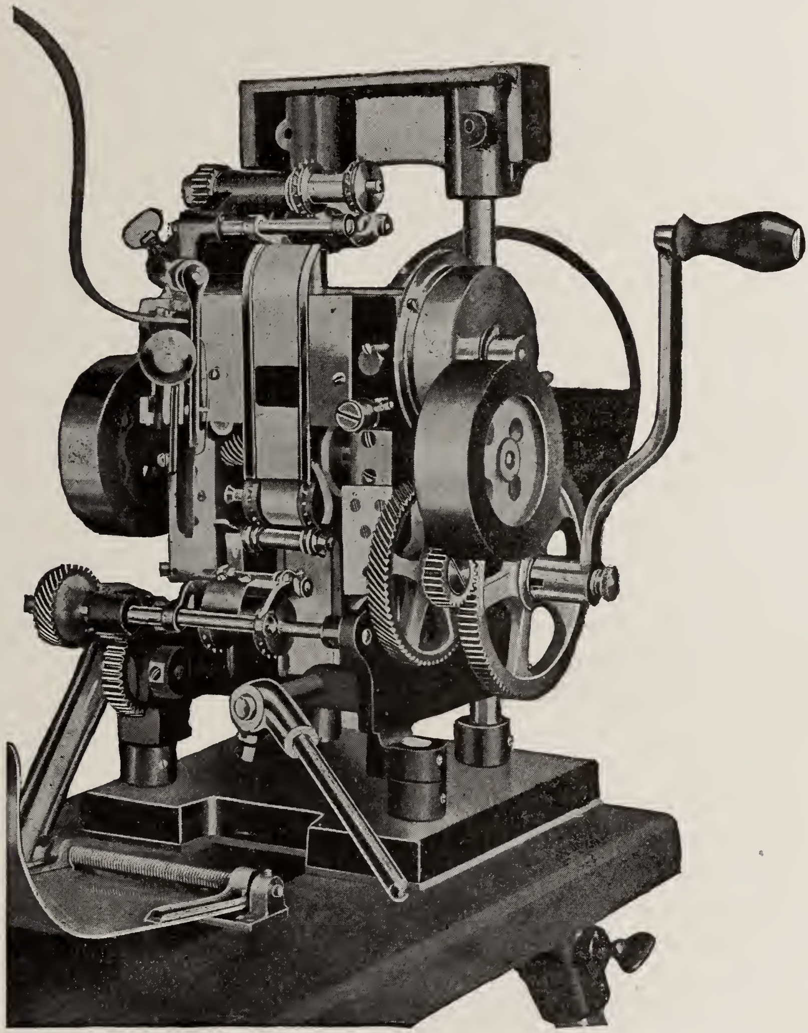


Fig. 105. Detailed View of the Lubin Motion Head

sprocket, press down the rollers underneath, lay the film around the right side of the sprocket and close the rollers to press the film against the sprocket, seeing that the teeth of the sprocket mesh properly with the holes in the film.

Open the film-gate door. Now press down the framing lever fully. This lowers the framing carriage. Bring the film between the door and the tension plate of the gate, carrying it accurately down through the film guide of the film gate, and close the door. This door may be closed before adjusting the film to the intermittent sprocket.

Pull up the film, so as to leave a loop big enough to place over your thumb between the top sprocket and the door rollers. Turn the fly wheel by hand until the middle sprocket—intermittent feed sprocket—starts, but before it moves any distance stop and open the presser rollers and place the film upon the middle sprocket, meshing it carefully with the teeth of the sprocket, and letting the presser rollers down upon it to hold it in place, the rollers pressing the film to the hubs of the sprocket teeth.

Now raise the carriage fully by means of the framing lever. Open the presser rollers of the bottom sprocket and place the film around the sprocket, but leave just loop enough to touch the back guard, putting the teeth of the sprocket properly through the film. Close the rollers, so that the film now lies between the bottom sprocket and the rollers, the rollers being on top.

Push the film through the two rollers in the bottom magazine, turning the handle of the motion head to give a sufficient slack to reach the arbor of the take-up device. Attach to the arbor in the usual way, take up the slack by turning the take-up reel by hand, then turn the crank a part of a turn to see that the take-up is working properly, and close the lower magazine door.

After everything is in place, turn on the light, but be sure that the fire shield is closed. When starting projection, press the main crank and handle somewhat toward the left. This will bring the friction clutch into action. Also notice before every projection of a reel that the automatic fire shutter is working properly. Should the fire shutter refuse to work, there is either oil or dirt in the friction clutch to which the chain is attached on the main shaft of the handle. Never oil the friction clutch. In case of dust or oil coming into this clutch, wipe it out clean and dry. Now open the door of the fire shield, turn the handle and proper projection may be made.

GENERAL NOTE

Before taking the instructions for any particular machine as final, remember that there are many general rules which apply to all machines, and these have been discussed under the subject of the motion head and motion-picture projection in general.

AUNTY LEARNS SHE HAS MARRIED A TRAMP
Scene from Photoplay, "What Happened to Aunty"
Courtesy of *Essanay Film Mfg. Co., Chicago*

MOTION HEAD

PART III

TALKING PICTURES

The histrionic stage holds a mirror up to nature. That is the text upon which a preliminary description of the art of the talking picture will be based. The motion picture reproduces, as a mirror would reproduce, the histrionic stage; the actors of the drama are voluble of lip and expressive of face and gesture, but they are silent. The motion-picture scene of the waterfall shows the tossing waves and the plunging masses of turbulent water, but the splash of the rapids and the roar of the cataract are not heard. In the motion picture of the rural summer landscape the trees may wave their boughs upon the picture screen and the atmosphere of the grove seems almost to pervade the theater, but the murmur of the breeze in the tree tops and the buzz of the cicada are not there.

The motion picture truly holds a mirror up to nature, but it is only an ordinary looking-glass giving back the scenes, but not the sounds. The talking picture promises nothing new from the picture screen, but promises to supply the missing sounds, to couple the senses of sight and hearing, and to make the reproduction of the subject complete, at least so far as drama and vaudeville may be concerned.

NATURE OF THE PROBLEM

To get a close understanding of the problem of the talking picture the experimenter may assume a position before a mirror, and, being in such position in fancy or in fact, he may talk, sing, laugh, or dance before it. If he should talk or sing, the lip movements would be reflected by the mirror exactly as produced by his lips. These movements he will see in the mirror. At the same time, he will hear his own voice, but not in the mirror or from the mirror. If he should dance, the faithful mirror gives back every movement to his eye, but does not give back to his ear the sounds of his feet upon the floor; those sounds are heard by his ears directly

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Now let the experimenter bring into his service the motographic camera. Again, he may talk, sing, laugh, or dance. The mirror is replaced by the sensitive photographic film, which receives the light much as the mirror did, but which records it as received. By processes of photographic development and printing and then by projection, the motographic film is made to give its record to vision, long after the experimenter has ceased talking, singing, laughing, or dancing.

What is this projected motion picture, recorded by the motographic camera and the sensitive photographic film? Just what the mirror gave back—the scene but not the sound. The photographic film was sensitive to light but not to sound, and recorded light but not sound, ultimately reproducing its record in light but not in sound.

Recording Sound. The phonograph, or graphophone, is hardly older than the motion-picture camera. Like the motion-picture camera, the graphophone has a recording surface but the surface is of a different nature and the method of recording upon it is different. The camera record surface makes a record of light; the graphophone record surface makes a record of sound. Like the camera, the graphophone may be made to give back its recorded message in the language of the record, light for the one and sound for the other.

How easy it seems for the experimenter to procure both a camera and a graphophone, and to talk, sing, laugh, or dance before both of them and then have both of them reproduce their respective records at the same time, whereby not only the sight but the sound of the speech, song, laugh, or dance may be reproduced at will from the inert records for the entertainment of the experimenter or others. With the first experiment at this duplex making of records, the feature of synchronism will become a prominent and probably an inharmonious one.

Synchronism. When the experimenter stood before the mirror, he heard the spoken word at the same instant that he saw the lips in the mirror move. He heard the sound of the step of the dance at the same instant that he saw the mirrored foot strike the floor. But in the reproduction, such a difference! The graphophone begins the song before the pictured man upon the screen has opened his lips; or the picture shows the experimenter singing or dancing in a manner familiar to all theatergoers, and in the midst of the motion picture the graphophone begins a song or a clatter which seems to have no relation to the picture. Synchronism is lacking. The experimenter now has learned that his two records must start together, or in proper relation, and must keep together, for when they are only a second apart in time, they are more ludicrous than when so far separated that they seem to have no relation at all.

The graphophone has not been perfected for the minor sounds of nature. The human voice is about the limit for the sound record. Voices and musical instruments are the standard repertoire of the talking machine, other records being the exception rather than the rule. This limitation of the graphophone limits the combination sight-and-sound entertainment to dramatic and vaudeville incidents, dancing and singing.

The tremendous demand for motion pictures which do not talk, the large number of theaters projecting motion pictures as the principal part of their program, and the avidity with which the theater manager investigates novelties to please his patrons, all indicate that a successful talking picture with a reliable system of projection to maintain synchronism between picture and speech would meet with a royal welcome and bring a rich reward to its promoters. Thus it has become the dream of inventors to combine those two devices, the motion picture and the graphophone, successfully, but always the stumbling block has been synchronism.

Not only must the picture film and the talking record be capable of synchronism, but means must be provided whereby they may be kept in synchronism either automatically or with a minimum amount of skill on the part of the theater operators. Synchronism, therefore, must be considered in two phases: *first,* making the photographic record and the sound record in such relation that reproduction in synchronism is possible, and, *second,* reproducing them properly as intended in their manufacture.

If the graphophone record and the picture film must be projected at the same speed to keep them in unison or in synchronism as required, may not both be put in a single machine equipped with sound reproducer and a projecting lantern? In toys this is practicable, or in a home exhibition, but in a large theater the motion pictures are projected from behind the audience, passing over their heads to the picture screen and being appreciated by the audience only as rays passing from the screen to the eye. If the graphophone were located with the projecting machine for the pictures, the sound would come to the audience from behind, which would be unnatural. Instead, the sound must come from the front of the theater. This limitation compels the location of the phonograph at or near the picture screen, while the projection machine must be at the back of the theater.

Only by projecting the pictures upon the back of a translucent curtain and permitting the graphophone to talk through the curtain may the two devices be located together.

The two machines, motion-picture projector behind the audience and graphophone in front of the audience, may be kept together in speed by some relation of propelling or controlling means. It is in this feature that inventors have been most active, and it is in this feature that the differences will be found in analyzing and comparing the different "talking picture" machines and systems offered and to be offered upon the market.

Length of Records. Theoretically, there are no limitations of length of a talking picture, for the second talking machine may be started just as the first talking machine is stopped, and the third disk of the series may be placed upon the first talking machine to be started just as the second one has stopped. Likewise, with two projecting machines, the second reel of film may be started just as the first is stopped, and the first projecting machine then may take up the third reel just as the second is finished.

With a single talking machine and a single projecting machine, the limit is reached with the talking machine first. The maximum talking record in America is the 12-inch disk running five minutes. The 10-inch disk runs three to four minutes, while the "four-minute" cylinder record lives up to its name, running four minutes or longer. European records running fifteen to twenty minutes have been reported and will be of value in the talking-picture art when adopted for that purpose. Cinephone films are offered upon 10-inch disk records, each accompanied by 150 to 250 feet of motion-picture film.

The possibility of the longer talking picture is assured, for it has been done. As for long, continuous sound records upon a number of disks, there are already offered to the general public for use in private talking machines, records for the complete operas of "Faust" and "William Tell." These records may have motion pictures fitted to them, according to the methods of the manufacture of talking pictures, or records of equal length may be made from the same or other subjects, complete with picture films.

CLASSIFICATION

All of the suggestions as yet made for producing talking pictures may be brought under one of the following three classes:

(*1*) The two machines are driven from the same source of power and are so related to this source that their speed of reproduction is identical.

(*2*) The two machines are so related that one drives the other or controls the speed of the other directly.

(*3*) Index hands or the equivalent are provided for the two machines, and an attendant, by constant supervision, keeps these index hands in proper relation.

(*1*) **Unitary Machines.** In the unitary machine, the two machines, projector and graphophone, are built together and are driven by the same main shaft of the combined machine, which may be turned by a crank or motor of any kind. In such a device, it is necessary to be able to secure exact synchronism at the starting of the picture and sound records, or to provide some means of adjusting in order to enable the operator in charge to get his picture to catch up with his graphophone, or to permit his picture to slow down to let the graphophone catch up with the picture.

Long Main Shaft. An invention which places two machines in the first class is the system of providing a long main drive shaft under the floor of the theater, gearing it at one end to the graphophone and at the other end to the projecting machine. At the projecting machine end, a clutch should be provided, and if the start is not made in synchronism, so that an adjustment is required, the operator may throw out the clutch and turn the projector by hand faster or slower until he gets the picture in synchronism with the speaking record; then he may throw in the clutch again, and the main shaft, driven by a constant-speed motor of sufficient power, keeps the two machines in constant speed relation, projecting their two records at the same speed and in synchronism.

When a splice in the film passes, where a few images have been cut from the film in repairing it, the picture film will run ahead of the graphophone record and the operator must detach his projector from the main drive shaft until the two records are brought into synchronism again. A new film should run in synchronism from start to finish under this method of driving, but an old film which has many breaks and splices becomes harder and harder to operate in synchronism as its splices increase. A matter of three to six pictures cut from the film—one-fifth to two-fifths of a second in time of projection—is sufficient in most talking-picture records to render them very noticeably out of synchronism.

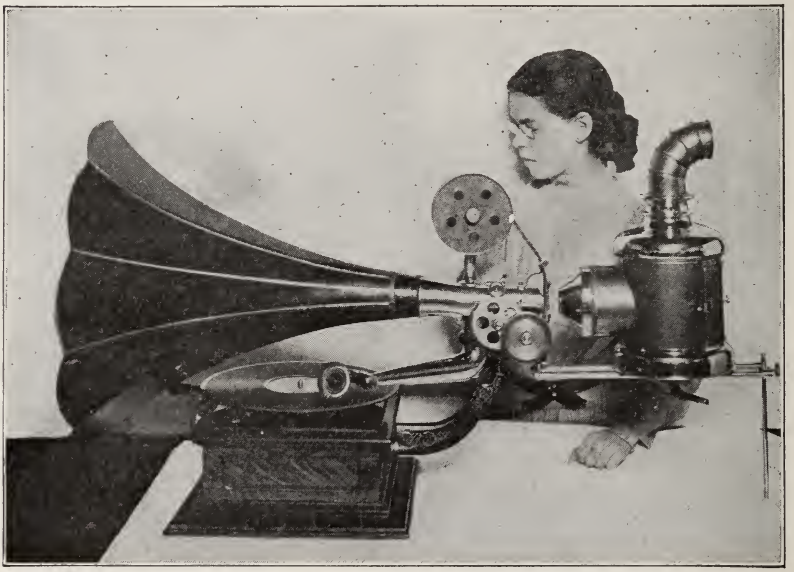

Fig. 105. The Photophone. A Unitary Talking-Picture Machine

Synchronous Electric Motors. There is an electric motor which is called a *synchronous motor* because when carrying its load it runs always in exact accordance with the speed of the dynamo which is furnishing the electric current for driving the motor. It is a motor operated by an alternating current, and its speed always is proportional to the speed rapidity or frequency of alternation of the current which drives it. When two such motors, just alike, are placed in service upon the same power circuit, driven by alternating current from the same central station electric dynamo, it follows that each will run at exactly the speed of the other. With one such motor driving the graphophone and another upon the same power mains driving the projecting machine, the speed of the record of the graphophone and projecting machine will be identical, proper speed gearing to the motors being provided. Any slight change in speed of the electric generator at the power station which is supplying the current for the motors, which of course would result in a slight change in the frequency of the current upon the power mains, is equally effective upon both the graphophone and the projecting machine, so that the two machines always move in unison, keeping the reproductions of their records in synchronism, if the records have been made properly.

Illustration. In the unitary machine, shown in Fig. 105, the motion head of the projector portion of the apparatus is built upon the support for the graphophone horn. The moving parts of the motion head are driven from the graphophone motor which turns the flat disk record under the reproducing needle of the talking machine. It is necessary only to set the graphophone needle to a marked point upon the talking record disk and to bring a marked picture image into the film window of the motion head, then start the motor.

To produce a compact combination device without permitting the horn of the phonograph to interfere with the beam of light of the projected picture, the lenses are arranged to project the picture through the horn, as shown in Fig. 105.

In this device if the motion head be disconnected from the graphophone motor, a crank may be attached to the motion head and the skill of the operator then may attain and maintain a synchronism which approaches perfection only by the degree of skill of the operator.

Two machines driven by the same source of power are shown in Fig. 106. The source of power in this instance is the operator's arm turning the crank in the projection room at the upper left-hand corner of the figure. The crank is attached to one of a pair of bevel gears in the operating room, and thus drives the vertical rod extending down through the floor of the operating room to a point below the floor of the theater. There, it transmits its power to the long horizontal main shaft extending under the floor of the theater to a point under the graphophone. The graphophone takes its power from this long horizontal shaft by means of a short connecting vertical shaft. Thus the projecting machine and the graphophone are driven by the same crank through an arrangement of gear wheels and shafts.

Any variation in the speed of the graphophone will change the pitch of the sounds being produced, a result which cannot be permitted in reproducing musical records, and which would be very objectionable in any sound record. On the other hand, the motion pictures must be projected at about the speed for which they were intended when made. This distinction exists, however, that while a small variation may be permitted in the speed of the motion pictures, no variation at all should be permitted in the speed of the graphophone reproduction. Hence, the graphophone must be driven at a speed as nearly constant as can be obtained by an acceptable motor, and the speed of the motion picture must be varied to bring the two reproductions together whenever for any reason or by any accident they lose their relation of synchronism.

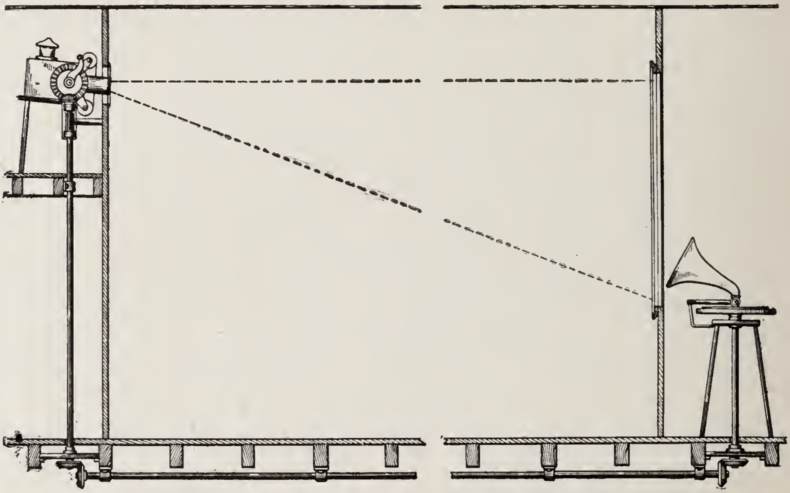

Fig. 106. Talking Picture Reproduction by Two Reproducers Driven from a Long Power Shaft

A splice upon an injured film will cut out a few images. Whenever this splice in the film passes through the motion head, the motion-picture film will begin to project its picture record ahead of the sounds from the graphophone, and the projector must be slowed down in speed until the graphophone catches up. Should the graphophone needle "jump a thread" or by any accident or a defect in the record fail to follow the record accurately, the projection operator must turn the projector faster or slower to vary the speed of the motion picture until the two records again are being produced in synchronism. It will be seen that in Fig. 106, to adapt the arrangement to practical work in a theater, the handle must be geared permanently to the shafting, and the motion head of the projection machine must have such a relation that it may run slower or faster in order to be capable of adjustment for synchronism.

(*2*) **Dependent Machines.** In this class of reproducing mechanisms for talking pictures, one machine must drive the other, or must control the other. As the variation in speed due to control, if any, must be impressed upon the picture projector and not upon the graphophone, the problem resolves itself into a constantly-driven graphophone either driving or controlling the picture projecting machine. Such a pair of dependent machines is shown in Figs. 107 and 108, the former showing the graphophone, and the latter, the picture projector motor.

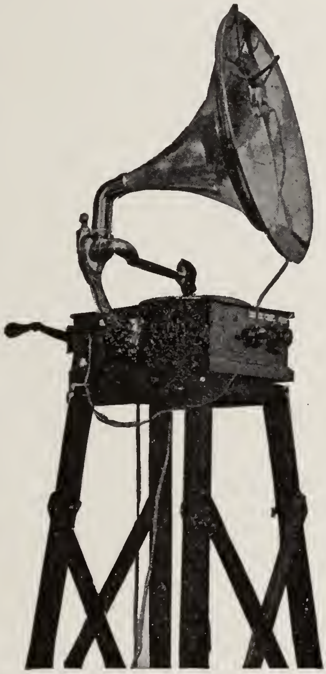

Fig. 107. Graphophone for Talking - Picture Reproduction, Sending Current to Distant Projecting Motor through Electric Cable

The machine illustrated is one brought out in Paris and invented by Captain Couade. The crank seen in Fig. 107 is the crank for winding up the motor of the graphophone, and not for turning the graphophone directly. This graphophone runs in the usual manner, and may be quite an ordinary type of talking machine, with the addition of a commutator for electric current which changes a constant potential to a system of intermittent potentials upon different circuits, the relation of the potentials produced by the commutators of the graphophone being likened to the related potentials of a three-phase alternating current. The electric commutator is inside the graphophone cabinet, the electric terminals and switches being seen in the figure upon the outside of the cabinet. The wires which lead from the graphophone downward carry the electric potential impulses created by the graphophone commutator. In Fig. 108 is shown the motor for driving the motion-picture projection machine. This figure does not show the projection machine, nor is it necessary to do so, since any projection machine may be used to project the picture film, provided only it is coupled to this special motor and driven by that motor at exactly the speed which the graphophone dictates by means of its electric commutator. The electric cable rising from the bottom of Fig. 108 to terminals upon the side of the motor is connected at its other end with the commutator of the distant graphophone, located near the picture screen of the theater.

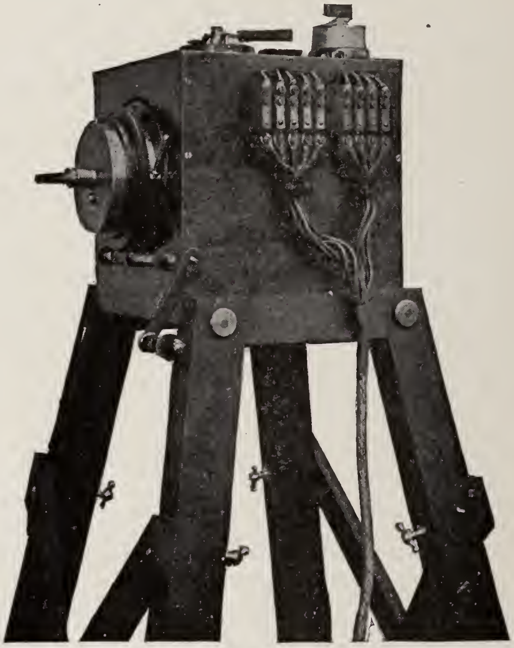

Fig. 108. Motor for Picture-Projecting Machine for Talking Pictures, Driven in Synchronism with the Graphophone by Current Received Over an Electric Cable

SCENE FROM PHOTOPLAY, "THE WAGER AND THE WAGE EARNER"
Courtesy of *Thomas A. Edison, Inc., Orange, N. J*

In operation, the motion-picture film is placed in the film gate and framed with a marked image in the film window. The needle of the graphophone then is placed upon the record disk at a marked point. These two marked points, one on the picture film and one on the sound record, were obtained in manufacture and placed upon the records when the records were made. They are points to which the records are in unison in time with reference to the light and sound of the subject.

The phonograph now is started and driven in the usual manner. The motion head of the projection machine, driven by the motor, gains speed as the phonograph gains speed, until both are running fully. If the projection machine is provided with an automatic fire shutter, the shutter will be lifted and permit the projection of the picture upon the screen as soon as sufficient speed has been attained.

In this device, the motion-picture projector is started by the graphophone, and it is run with the graphophone, stopping with the graphophone. The power for running the motion-picture projector is not created by the graphophone, nor by its motor, but it is so controlled by the commutator of the graphophone as to drive the motor and the picture machine at the required speed. The motor is so constructed as to be unable to turn under the influence of any direct current which may leak to it through the graphophone commutator while the graphophone is at rest. The operator at the projection machine must note any lack of synchronism and correct it, after which the records will stay together.

(*3*) **Dial=Regulated Machines.** In this class of reproducing devices for talking pictures, the talking machine and the picture machine are separate, and each has an index hand. The index hands need have no direct relation to each other nor any direct connection with each other, but each serves to show the speed at which its associated machine is being driven. The graphophone being driven at a constant speed, its index hand will revolve at a constant speed, and the projection machine operator then must turn his crank at such speed as will make the picture machine index hand keep up with the pace of the graphophone hand, and not run ahead of it.

Greenbaum. In Fig. 109 is shown a diagram of the system and some detail of the apparatus of the Greenbaum device. In the figure, at the upper left-hand corner, is shown a commutator upon a shaft which is mounted in connection with the shaft of the motion-picture projector. At the upper right-hand corner of the figure is shown a similar commutator which is mounted upon a revolving shaft which is associated with a shaft of the graphophone. The device forming the lower part of the figure is a dial which is mounted in the operating room, in front of the operator who is turning the crank of the motion-picture projector. Upon the dial are seen two index hands, *24* and *29*. The hand *24* is driven by the picture projector and the hand *29* is driven by the graphophone. When the two machines

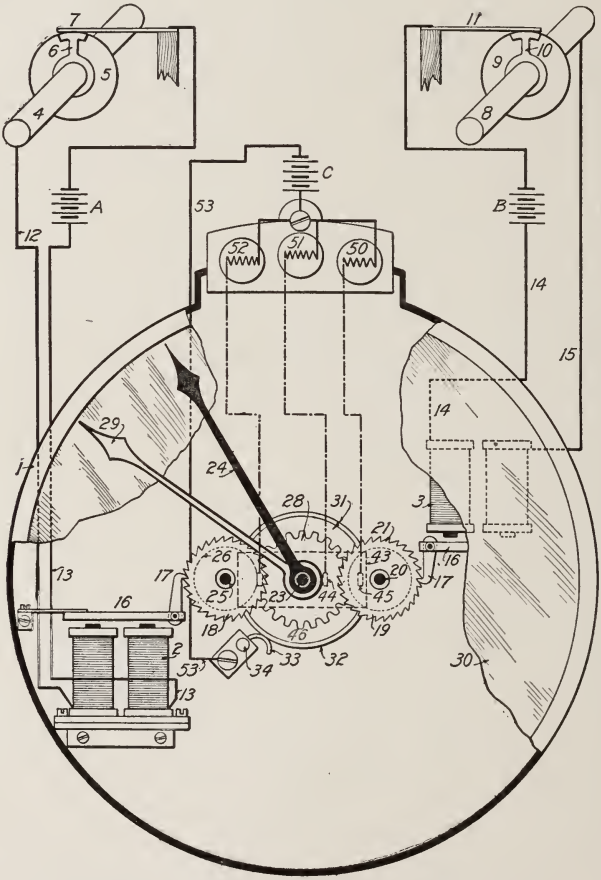

Fig. 109. Greenbaum Mechanism for Synchronizing Talking Picture

are running in synchronism, the two hands will maintain a constant angle between them, preferably being together, that is, the hand *24* should cover the hand *29*. By reason of splices in the film, or by accident, the hands may become separated, in which case the angle between them must be kept constant by the projection-machine operator.

Electric incandescent lamps also are provided—as shown by the circles 50, 51, and 52 in the figure—and are so arranged that lamp *51* will glow when pictures and talking record are in unison; lamp *52* will glow if the pictures are behind time; and lamp *50* will glow if the pictures are ahead of the talking record. The lamps, as well as the hands, serve to guide the projecting operator to keep the two records in synchronism.

The mechanical arrangement of parts in the Greenbaum device is as follows: In the case *1*, the two electromagnets *2* and *3* are mounted. Electromagnet *2* is connected by electric wires *12* with the electric commutator device of the shaft *4* pertaining to the projector, in such manner that every time the commutator of the shaft *4* closes the electric circuit an impulse of electric current will flow from the battery *A* through the wires *12* and the commutator and the magnet *2* to cause the armature *16* of the magnet *12* to be attracted. This, by the action of the pawl *17*, drags the ratchet wheel *18* down one tooth; this ratchet wheel in turn by a pair of gear wheels drives the shaft of the hand *24*, moving the hand *24* a short step over the dial *30*. One such step of the hand *24* is made for each revolution of the shaft *4* of the projector, hence the speed of the movement of the hand *24* is a measure of the speed of the projector.

In like manner, electromagnet *3* is connected by electric wires *14* and *15* with the electric commutator device of the shaft *8*, pertaining to the talking machine, in such manner that every time the commutator of the shaft *8* closes the circuit an electric impulse will flow from the battery *B* through the wires *14* and *15* and the commutator and the magnet *3* to cause the armature *16* of the magnet *3* to be attracted. This by the action of the pawl *17* drags the ratchet wheel *19* up one tooth; this ratchet wheel in turn by a pair of gear wheels turns the tubular shaft of the hand *19*, moving the hand *29* a short step over the dial *30*. The hands *24* and *29* move in the same angular direction, and when the records are being rendered in unison they move at the same speed.

It is necessary, in starting the devices to render a talking picture, to place the film in the motion head with a marked image in the film window, to place the needle of the talking machine upon a marked place in the record, then to place the two hands of the indicator together. After that, if the hands are kept together, the records will be kept together as the records are reproduced. The passing of splices where images have been cut from the picture film will cause the hands to separate if synchronism is maintained by the operator, since the projection operator must slow down his machine to regain synchronism, after which the relation of the hands is maintained at the new angle.

Cinephone. The cinephone system of talking-picture production will appeal alike to the projection operator and to the practical theater manager, and for the same reason, namely, that it has a minimum of special apparatus in the theater, and it requires the least specialization of skill on the part of the projection operator.

The cinephone as offered to the public is in substance only an attachment for a well-known type of talking machine. As built it is a quick-starting talking machine having an unusually heavy spring which permits it to obtain its full speed and volume of sound almost instantly upon the release of the ordinary brake which sets the disk record revolving. It may be used for ordinary disk records for entertainment between pictures, or for illustrated songs, without the cinephone motion-picture films, which in connection with the talking machine produce the talking pictures.

The cinephone talking machine stands at the side of the picture screen and faces the audience and the projection operator. It has an illuminated dial upon its front face, upon which there is an illuminated revolving hand. The course of the hand is marked by four green bullseye lamps, readily discernible by the projection operator in a darkened auditorium, even at a distance of two hundred feet.

The illuminated dial and hand are for the purpose of registering the exact speed at which the talking machine is operated. A similar dial and hand are photographed into the motion-picture film, the hand of the motion-picture film traveling over a circle which is marked by four white bullseye spots upon the picture screen. This second dial and hand appear in the lower left-hand corner of the film picture and of the screen when the picture is projected upon it.

As the picture is shown, the dial hand in the screen and the dial hand upon the front of the talking machine both move in the same direction and at the same speed. The projection machine is operated at a speed calculated to keep both dial hands at the same point upon the dial circumferences at all times. So simple is this, that anyone can be taught to produce cinephone synchronism in a few moments.

Any projection machine already in use may be used under this system of synchronism and any ordinary operator can master the additional detail quickly and show a finished talking picture.

There are no connections, electrical or otherwise, between the cinephone talking machine and the picture screen, nor between the cinephone talking machine and the projection machine. The operators required are the projection-machine operator and the pianist or other musician or regular attendant of the theater to make the change of records and rewind the talking-machine motor, and to start the talking machine when the starting flash is received from the picture projector. It is the intention of cinephone design that the number of employes of the theater need not be increased, and that no special skill be required of any of them.

MANUFACTURE

The theoretical method of recording action and speech, by locating a recording graphophone and a motion-picture camera properly near the speaking actor, has limitations. The graphophone must be near the speaker, or it will not record the speech, while the camera requires some intervening distance in order to secure a proper rendering of the picture. Yet the graphophone must not appear as an object in the picture obtained by the camera.

Small Subjects. A very delightful and thoroughly successful talking picture, or better "singing" picture, is that of a canary bird singing in its cage. The actual area pictured by the camera is only about a square yard, with the bird near the center, so that the graphophone recording horn could be brought within 18 inches of the bird without appearing in the picture made by the camera. In this manner, the two records could be made simultaneously, and when reproduced they are capable of absolute unison when properly synchronized and uniformly driven at the proper speed.

A talking picture of a "laugh" in which the laughing face is taken by the camera at close range, to fill the entire space of the picture image, being then projected to fill the entire picture screen, may be made in the same manner. Even in the case of a monologue by a single actor, where the actor standing before the camera fills the picture image space to the top line, the limit of the field of the camera may be determined very accurately and the recording graphophone horn may be placed just above the limit of vision, that is, just above the picture as projected upon the screen.

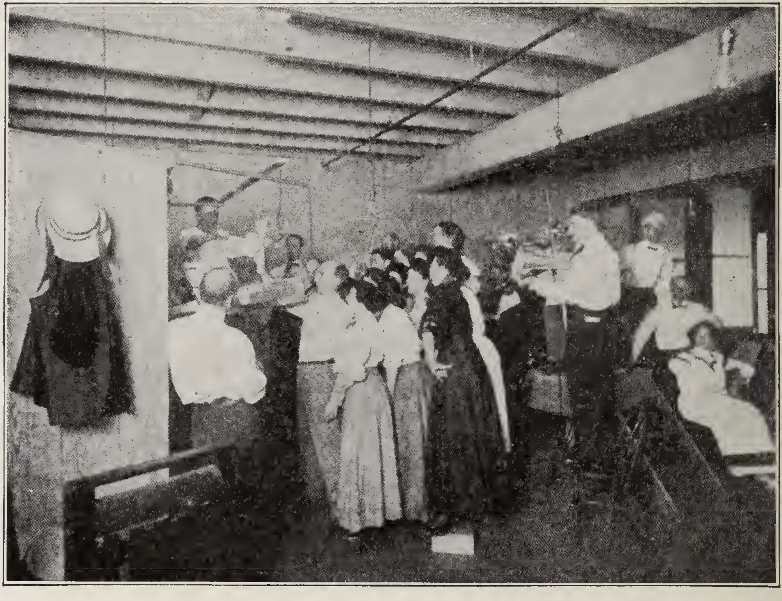

Fig. 110. Producing the Talking Record for a Talking Picture

Large Subjects. In producing a talking picture where several actors are involved, the method of manufacture is to make the talking record first, and then fit a motion picture to it. To do this, the actors are well drilled in their parts, so that they will be able to produce the performance twice, once in sound for the sound record and once in action for the picture record.

The actors being thus trained, the sound record is produced without any reference to what the appearance of the actors may be while producing the record, the end desired being only that the best possible sound record be obtained.

A group of actors producing a sound record is shown in Fig. 110. They are standing compactly grouped, facing the recording graphophone. The stage director stands coatless above them. In Fig. 111, the next step of the process is shown, namely, that of training the actors into unison with the sound record already produced. In the foreground is seen the horn on the talking machine. It is rendering the sound record. Before the horn stand the stage director and a group of the actors. The actors are repeating the words which they used in making the sound record, repeating them in unison with the talking machine, and at the same time suiting the actions to the words. As yet the camera has not been brought into use, for the sound record may be made indoors, and the rehearsal for action may be made indoors as well, but the making of the picture must be done in the field before a suitable background or in the studio in a proper stage setting.

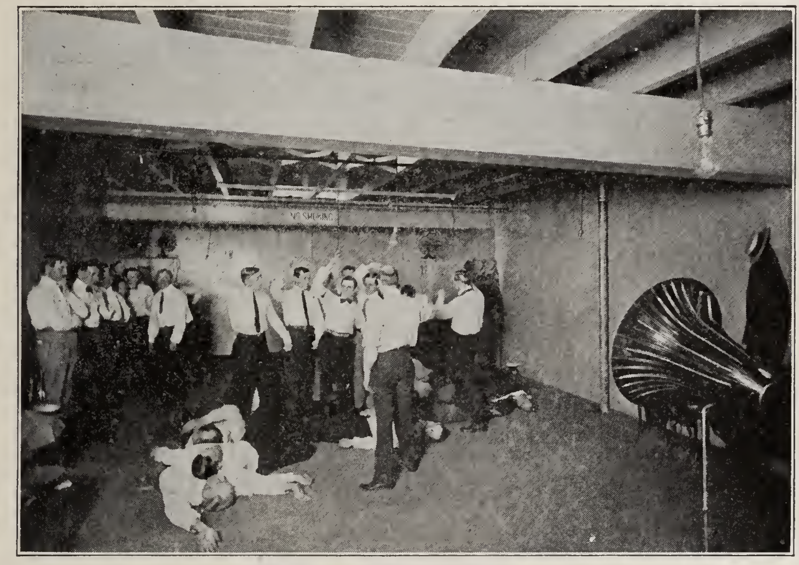

Fig. 111. Drilling the Actors before the Graphophone to Attain Unison with the Talking Record before Making the Picture Record of a Talking Picture

Talking=Picture Camera. The combination camera and talking machine for the final step, namely, the making of the picture record, to fit the talking record, is shown in Fig. 112. At the left is the reproducing graphophone; at the right is the motion-picture camera. Both are mounted upon tripods, for use in field or studio. Connecting the two machines is a driving shaft, and upon the tripod with the camera is mounted an electric motor for driving the shaft. This combination machine is started, the actors act and speak in unison with the talking machine, and are photographed by the camera. Even the words of the talking machine must be repeated in unison with the machine, that the lip movements of the actor in the motion picture may be synchronous with the spoken words of the talking machine.

The photographic negative is developed and prints are made. The starting point now is marked upon the sound record and upon the picture film, and the two records are ready for delivery to the theaters for the production of talking pictures.

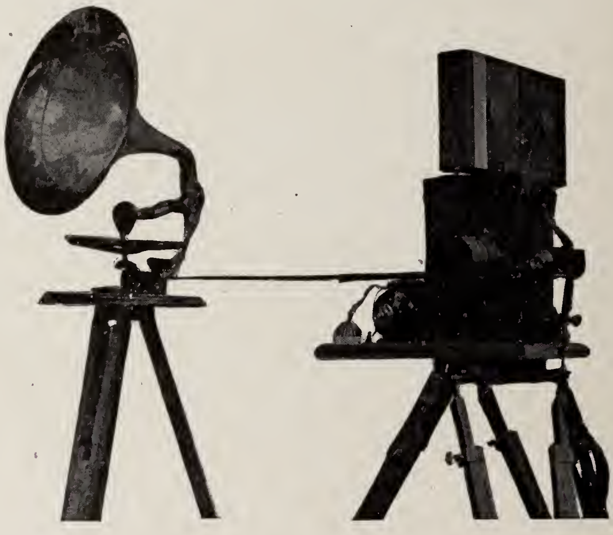

Fig. 112. The Recording Motion-Picture Camera Coupled to the Reproducing Graphophone for Producing the Picture Record of a Talking Picture

REPRODUCTION OF TALKING PICTURES

Operation of the Cinephone. The picture screen and talking machine of a theater with the cinephone in operation are shown in Fig. 113. Note the dial upon the talking machine, and the similar dial in the lower left-hand corner of the picture upon the screen. Note

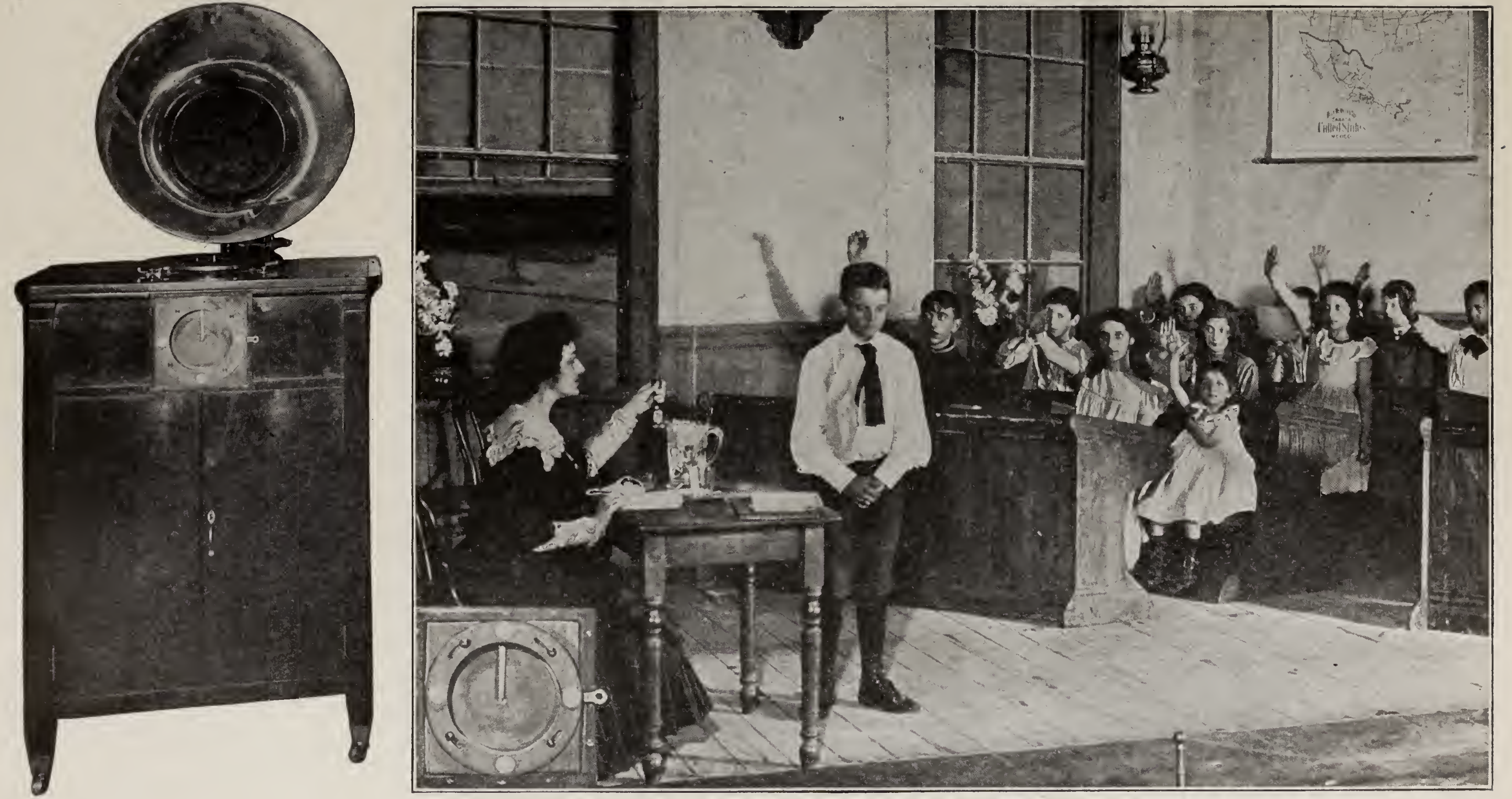

Fig. 113. The Cinephone in Operation

also that the hands upon the two dials occupy the same relative positions.

Starting in Synchronism. The pianist assists the projection operator by managing the talking machine. The talking machine is turned slowly by the motor or by hand until the index hand is in an upright position, pointing to the top lamp of the four which surround its dial and which appear in Fig. 113 as four black spots, above, below, to the right, and to the left, respectively, of the dial on the front of the talking machine. The disk record then is placed on the carrier with its marked point under the needle. A groove is cut in the disk to guide the needle to the starting point of the record. The motor of the talking machine is wound and the talking machine is ready for action.

During this process, a small incandescent lamp has been burning upon the top of the talking machine; when all is in readiness, this lamp is turned out by the pianist as a signal to the projection operator in the operating booth that the talking machine is in readiness.

The projection operator threads his leader through his motion head in the usual manner, there being no special marked points to be observed, and begins projecting the film at the cinephone speed of eighteen pictures per second, or about sixty-six feet per minute—a speed one-third greater than the usual picture speed. All initial leader and title having passed, and the portion of the picture having been reached where the talking machine is required, there appears upon the picture screen, for a fraction of a second only, the words, ' The Cinephone." This is the "starting flash," usually stained yellow and, therefore, called the "yellow flash," which is the signal for starting the talking machine. The pianist, who has been waiting with hand on starting brake of the talking machine, draws the brake away from the record carrier.

The talking machine starts at full speed, and the index hand of the talking machine also starts revolving. At the time of the starting flash, the index hand of the picture film is vertical—note the lower left-hand corner of Fig. 113—and so corresponds with the vertical position of the index hand of the talking machine.

Maintaining Synchronism. The operator turns the projecting machine at the proper speed to keep the two index hands together, and the two records will remain in synchronism through the entire picture. The cinephone speed is faster than the ordinary picture speed, the cinephone film running fifteen minutes to the reel while the ordinary film runs twenty minutes to the reel, but the ordinary projecting machine will stand successfully the strain of the somewhat higher speed.

The index hand for the picture screen dial is photographed into the cinephone picture film, and requires nothing special upon the projection machine for the projection of the index hand. Splices are self-correcting in the cinephone film, because when a few images are cut out of a strip of film, the index hand for those images is cut out also.

The index hand makes one revolution upon the picture screen for every 14 feet of picture film. This gives the hand a speed of revolution of about four and three-quarters turns per minute, or one turn in about thirteen seconds, the talking-machine hand having the same speed also. If, by some accident, the projection operator is compelled to cut out a piece of cinephone film, say even as much as 3 feet of it, the splicing of the film will cause a jump in the pictures which will take them out of synchronism with the talking machine. In such a case, the index hand upon the picture screen will appear to jump also, just the same as any other moving object upon the picture screen. For a 3-foot loss of film, the index hand will jump a quarter of a revolution, and be a quarter turn ahead of the talking-machine index hand; the projection operator then slows down his motion head until the talking-machine hand catches

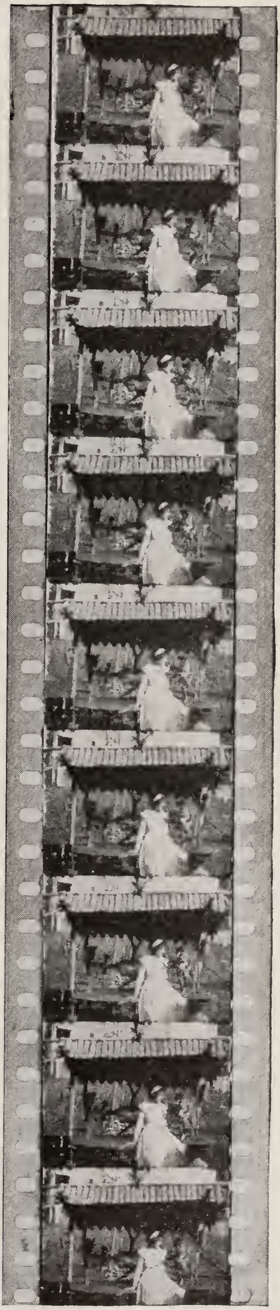

Fig. 114. A Specimen of Cinephone Film

up for the loss, and within ten seconds the synchronism will be restored for the loss of a yard of film. Ordinary splices, where but from one to six of the little pictures are lost, pass without notice, being almost instantly and unconsciously corrected by the operator, whose eye is constantly upon the two hands.

In case the talking machine, because of a defective machine, a defective needle, or a defective record, should "jump a thread," the projection operator will notice it, turning either faster or slower until synchronism is attained by letting the index hands separate, then turning at the standard speed until the end of the picture, keeping the index hands steadily apart at the distance caused by the loss or gain of the talking machine. With a talking-record disk driven at seventy-eight revolutions per minute, the usual speed for Victor records, a loss or gain of a thread upon the record makes a difference of one-sixteenth of a revolution of the index hands. That is to say, the gear between the revolving record and the index hand is about sixteen-to-one.

The excess speed of the cinephone film, 66 feet per minute instead of 50 feet per minute for standard projection, will enable the operator to turn his motion head for cinephone film at three-quarter speed without causing an objectionable flicker upon the picture screen, thereby enabling the talking record to again come into perfect accord with the picture film, that is, enabling the index hand of the talking machine to catch up with the index hand of the picture screen.

A specimen of cinephone film is shown in Fig. 114, showing the index dial and hand photographed into the lower left-hand corner of each of the images.

COLORMOTOGRAPHY

Color photography with the fixed camera has been an accomplished fact for several years, but the production of colored motion pictures, in the colors of nature, by photography direct from nature with color-sensitive photographic films, has only lately reached two solutions, one of which is called the Urban-Smith process and the other the Friese-Green process. Both of these have been exhibited publicly. Other processes are promised, but the promises are as yet unfulfilled.

URBAN-SMITH PROCESS

The motion picture itself, the black-and-white kind, utilizes the persistence of vision for the production of motion in the picture, simulating the motion of the subject photographed. The Urban-Smith process utilizes the persistence of vision still further, causing it to produce also color in the picture simulating the color of the subject photographed. Obviously, it would be possible easily to reproduce in blue upon the picture screen a picture which has nothing but blue in the subject photographed; or the same is true of green if the subject had nothing but one shade of green in it; but when the subject has both blue and green, and perhaps red and yellow as well, how shall these colors be preserved separately and combined upon the screen when projected?

The Urban-Smith answer to this question is that they may be photographed separately and then thrown upon the screen so rapidly one after another that the eye of the spectator (by the persistence of vision) sees all of them at once. This fundamental principle of recording and reproducing the colors of nature has been worked out in a practical form for motion-picture theaters, and has been named "Kinemacolor." The working colors of the photograph have been reduced to two, green and red (or orange). The film when examined before projection appears quite the ordinary black and white film; the color is given to the light rays after they have passed through the film. The pictures are projected at thirty-two per second, or 120 feet of film per minute, a speed about two and one-third times as fast as the usual projection of ordinary motion pictures.

Making Kinemacolor Film Pictures. The camera is provided with a double shutter, having two windows, making sixteen revolutions per second, while the sensitive film is shifted thirty-two times per second. This corresponds to the number of exposures, since the shutter with its two windows makes two exposures upon the film for every revolution of the shutter.

The film is sensitive to light of all colors, and the shutter carries in each of its windows a sheet of colored gelatine, one window being colored green and the other window being colored red or orange. Thus, when the strip of sensitive photographic film has been exposed in such a camera, and subsequently developed into a negative, it has upon it one picture taken through a green window with green light only, and the next picture taken through a red window with red light only, and so on alternately for the entire length of the film. In addition, a spot is printed opposite each green-light picture to identify the green-light pictures from the red-light pictures, for all of the images in this negative film are merely black-and-white, without any traces of color whatever.

From this negative, a positive print is made, exactly as for a black-and-white picture. The guide spots for the green-light pictures are transferred to the positive print and serve to identify the green-light pictures in the positive. The Kinemacolor film for the projection of motion pictures in natural colors now is complete and ready for the Kinemacolor projecting machine. No coloring whatever is found in the film. Then how are the pictures to be projected in color?

Production of Color. It is generally known that all of the tints and hues of nature can be reproduced by a correct combination of three elementary colors in proper proportions. Red, yellow, and blue usually are used as a set of elementary or primary colors, but orange, green, and violet serve as well.

Printing presses turn out daily numberless pictures in colors, calendars hang upon the walls, and picture postcards travel through the mails in flocks, bearing the colors of nature. Yet examine them, and the largest number of them will be found to have met the printing plate but three times, once for each of three colors, usually red, yellow, and blue, yet each shows a wide variety in number of colors and a wide variation in tones of each color. It is by the combination of the primary colors in proper proportions that these effects are attained, and the same principle is used on the Urban-Smith process of color motography.

On the postcard, the colors will be found to be made up of numberless small spots of the primary colors, intermingled, so that the eye sees none of them separately, but all together, the colors being mingled in the eye. The Urban-Smith process also throws from the screen to the eye the different primary colors in different quantities from the same spots on the screen, and the colors mingle in the eye by the persistence of vision to produce a wide variety of shades and tintings.

Flag in Color. There is presented in Fig. 115 a reproduction of a Kinemacolor photograph of the British flag, a flag which has a blue field crossed by red stripes, with lines of white bordering the red stripes and separating the red and blue. The spot for identifying the green-light picture is visible in the margin between the perforations, opposite the second and fourth pictures, counting from the top of the figure. The first and third pictures, counting from the top, are the red-light pictures.

For purposes of study, consider that these small pictures are cut apart, that the first picture is placed between two lantern-slide cover glasses of clear glass and projected upon the picture screen, and that the second picture is placed similarly between the two other cover glasses of clear glass and projected from a second lantern upon the same screen and upon the same spot of the screen, so that the two flags from the two lanterns will be focused upon each other upon the picture screen. The audience will see but one flag, not realizing that the one picture is projected from two lanterns.

Note that the second lantern has the picture with the green-light spot, therefore, it has the green-light picture, so slip a sheet of green gelatine over the slide, and at the same time slip a sheet of red (or deep red-orange) gelatine over the picture in the first lantern. This produces a beam of green light from one lantern and a beam of red light from the other lantern, but when they fall upon the picture screen on the clear space all around the flag pictures they will both be seen by the eye at once and the combination will give a white light, or nearly so; hence the flag will be seen upon a white background with the colored beams of light, just as it was before the colored gelatine sheets were put into the lanterns.

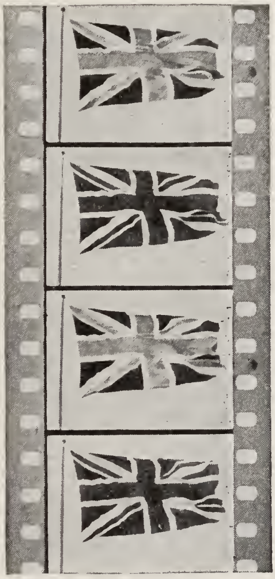

Fig. 115. A Kinemacolor Flag

The same is true of the lines along the edges of the stripes or cross-bars of the flag, but with the bars themselves it is different.

Note that the top image, or red-light image, is clear in the cross-bars, while the second image with the green-light spot is dark in the cross-bars. Then the red-light lantern, with the red gelatine color screen and the red-light image of the flag, will project red light upon the cross-bar portion of the flag, but the green-light lantern, with the second or green-light image, which is opaque in the bars, will be unable to project any green light upon the bars of the flag on the screen to change the red light to white, hence the bars of the flag will be seen red by the audience. In the space of the blue field of the flag, a little red and a little green light will be projected through the half-tone of the picture film, combining to produce the blue of the flag.

Alternate Projection. In the Kinemacolor projecting machine, the red-light flag and the green-light flag are not projected at the same time, as was considered with the two lanterns for purposes of analysis and study, but they are projected one after the other so rapidly that the eye retains the red picture while the green picture is being projected, and then in turn retains the green picture while the next red picture is being projected, thus actually seeing both pictures at once by the principle of persistence of vision.

The beam of light from the picture film is colored red and green alternately by a shutter upon the projecting machine similar to that in the camera with which the pictures were taken. The shutter has two windows, one of which carries a piece of red or orange gelatine and the other of which carries a piece of gelatine colored green. The green gelatine is in front of the lens while the green-light image is being projected and the red gelatine is in front of the lens while the red-light image is being projected. In this manner, the different images are projected with the color of light which made the negative in the camera, and the light given to each portion of the screen is of the same color and density as that which made the corresponding portion of the negative, which is to say, the same as that which was given to the lens or to the eye of the observer by the actual scene motographed. Because of the speed of projection and the principle of the persistence of vision, the red-light pictures and the green-light pictures are blended together in all portions of the picture screen at once, so that the eye sees the view as it appeared before the camera, with all its colors and gradations of color and light and shadow in all its different parts.

SCENE FROM PHOTOPLAY, "ONE OF NATURE'S NOBLEMEN"
Courtesy of *Selig Polyscope Co., Inc., Chicago*

Fig. 116 shows a reproduction of a water scene motographed in Kinemacolor film.

Kinemacolor Machines. The Kinemacolor film is made to be projected at a speed two and one-third times as great as ordinary black-and-white film. No ordinary machine will stand the strain of such a speed of projection, and a special Kinemacolor projecting machine has been built for the work. The machine should be run by a motor, the power required to drive it at its high speed being almost too great for the arm of the operator, although a short length or a single reel of Kinemacolor may be turned through by hand. A reel of one thousand feet of Kinemacolor film runs but eight minutes on the picture screen. Let any operator try to turn a full reel through an ordinary projecting machine in eight minutes and an idea will be had of the power and speed required of the Kinemacolor projector.

The Kinemacolor projector is fully adapted for the projection of ordinary black-and-white, 50-feet-per-minute film, merely by removing the color screen, or shutter having the colored windows, and then turning the machine at a proper rate of speed for fourteen images per second instead of thirty-two.

All of its parts are similar to the generally known projecting machines of America, except the intermittent mechanism for the shift of the film, and the removable color shutter. The machine when equipped for color projection carries two shutters, the simple shutter for black-and-white pictures being left on when the additional color shutter for Kinemacolor pictures is added. A view of the operating side of the motion head is shown in Fig. 117 and a view of the color screen or color shutter is shown in Fig. 118.

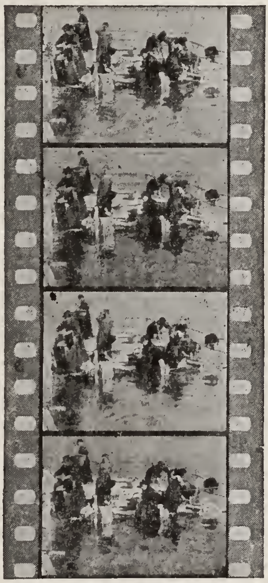

Fig. 116. A Kinemacolor Water Scene

Intermittent Mechanism. The intermittent sprocket of the ordinary type of projecting machine is replaced by a device of the beater class, shown at *66* and *67* in Fig. 117. This beater cam pulls slack into the bottom loop of the film at every revolution, drawing the film down through the film gate just as the intermittent sprocket does in the usual type of American machine.

In threading, the film is carried over the beater dog as it would be carried over the intermittent sprocket, except that there are no teeth to enmesh, and no presser roller for the beater dog. The course of the film through the motion head is seen very clearly in Fig. 117. The upper loop between the upper steady feed sprocket and the film gate should be rather small when the beater dog has just drawn the film down.

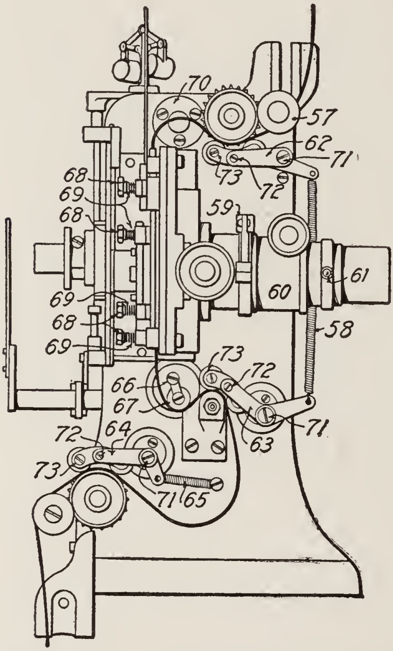

Fig. 117. The Kinemacolor Motion Head

Adjustment of Color Screen. The color screen is made of thick sheets of gelatine clamped between steel frames, as shown in Fig. 118. Not only is the steel frame capable of being removed from the shutter shaft which carries it upon the projecting machine, but the sheets of gelatine are capable of being removed from the frame.

The red gelatine is used in a single thickness, but the green gelatine is used in two parts, first a single thickness covering the whole of the green window, then another piece of green covering the middle portion and giving a double thickness in the middle of the window. The object is to permit an adjustment of the relative volume of light in the red-light and green-light pictures, or in the red-light and green-light beams of light thrown upon the screen by the motion head through the color shutter when there is no film in the film window. When the color shutter is adjusted properly, and the Kinemacolor motion head is turned rapidly with no film in the window, the picture screen should appear white. This is an adjustment that the Kinemacolor operator must make.

The color of the red gelatine in the color shutter is a standard and, therefore, should not be changed. Were the color shutter put in the machine with only a single thickness of green gelatine, the screen would be greenish white when the motion head is turned rapidly without a picture film in the film gate, and all pictures when projected would take that greenish tint. On the other hand, were two thicknesses of the full size of green gelatine placed in the shutter, the screen would appear a light orange.

The size of the smaller piece of green gelatine must be adjusted until the screen appears a clear white. This is the best adjustment attainable, and when done has adjusted the color shutter to the color of the arc lamp. The adjustment should be made with the arc of medium length, not just after feeding, nor just before feeding is needed. Nor should the color of the screen be judged just after looking at the arc, for the arc will have blinded the eye and will have rendered it impossible to judge the color of the screen.

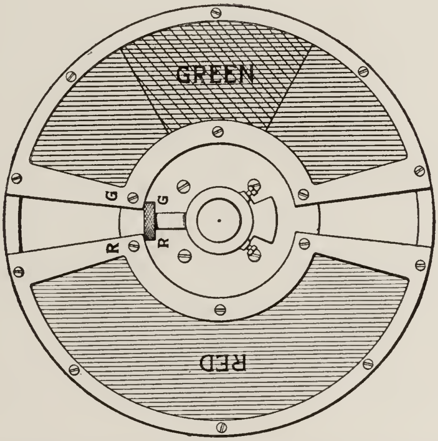

Fig. 118. The Kinemacolor Color Shutter, Showing Red-Light Window, Green-Light Window, and Open Spaces for Blue Light

The color shutter is so adjusted upon the shaft which carries it that either red light or green light will be admitted to the picture screen through the colored gelatine windows when the lens of the motion head is opened by the opaque shutter. The open slits of the color shutter will pass the lens while the opaque shutter has the lens closed. By inspection of the opaque shutter, it will be seen that the shutter is not black, but a dark blue, thus supplying to the picture screen a third tint through the open slots of the color shutter to correct some of the tints of the Kinemacolor picture when projected.

Framing. The Kinemacolor projecting machine has a larger range in framing than the ordinary machine, since it is necessary to frame to either one of a pair of pictures in the strip of film. Thus an image may be accurately centered in the film window when the film is at rest between shifts of the intermittent movement, and when the shutter therefore is open, but if the image be the red-light image and the shutter window just then before the lens be the green-light gelatine window, then the film must be framed forward or back one whole picture image to bring a green-light image into the film window for the green gelatine of the color shutter.

Framing Titles. To assist in the proper framing of the pictures for color before the actual pictures begin to be projected upon the screen, the titles are made in the green-light images only, the red-light spaces being left of blank, black film between the green-light title images.

The title, therefore, must be framed to green as well as framed to center in the film window and upon the picture screen. If the title comes red-light upon the screen, frame it up or down a full picture, making it green. The picture which follows then will come in its proper colors.

Splicing. Owing to the hard usage of the film because of its projection at such a high rate of speed, the splices must be strong. The splices should be a half-picture or two full sprocket holes, instead of a quarter picture or only one sprocket hole, as is the case with ordinary film. By the beater type of shift mechanism, there is no intermittent or high-speed sprocket. All of the sprockets are steady feed and reasonably low speed, hence able to negotiate the less flexible splice better than the sprocket shift.

Splicing for Alternation. This is splicing for color. The pictures in the unbroken film come red-light, green-light, red-light, green-light, and so on, and this order must be preserved when cutting out a bad spot in the film and splicing up. Always cut an even number of images. Cut out one and a half and lap a half, thus making a cut of two images, or four, or six, as may be necessary. If a single red-light image were cut out, it would leave two green-light images together. When that point would be reached in the projection of the film, the second of the green-light images would get the red-light window, the next or red-light image would get the green-light window of the color shutter, and so on, every image getting the wrong color from the color shutter. Every object in the picture upon the screen showing any color at all would change its color. The trees would turn red instead of green, the sky orange instead of blue. The picture upon the screen would be spoiled until the projection operator could notice the condition and frame the film backward or forward one whole image.

When it is found that a film changes thus in projection, a splice improperly made will be found at the point where the change occurs. This should be cut and respliced, taking out only one image, to change the film back to the proper alternation of red-light, green-light, and so on.

The green-light spot opposite the green-light images, shown in Figs. 115 and 116, will aid in making the splices correct for color, and will aid in inspecting any splices which may be found in a film not yet projected. In some Kinemacolor films, the green-light spot is not printed photographically, but is made by a spot of green dye or pigment upon the gelatine of the film, or by a short green line upon the margin opposite the green-light picture.

In the absence of either photographic spot or green mark, the alternation of pictures still may be observed in most Kinemacolor films by the comparative density of the images, or of some particular portion of the images. If there are green trees, they will be light and dark in alternate pictures, being lighter in the green pictures. The sky if blue will be lighter in the green pictures, but if gray or cloudy it will be of about the same density in both. Perhaps a dress or house may give the light-dark-light-dark alternation, and in splicing it matters not which is light and which is dark, so long as the alternation of light-dark-light-dark for the series of pictures is continued properly over the splice.

In Fig. 115, the bars of the flag give the light-dark alternation, being light in the red-light picture, while in Fig. 116 the sky gives the light-dark alternation, being light in the green-light picture.

Film Inspection. A Kinemacolor film should be inspected thoroughly by the careful operator, who is jealous of his results and of his reputation, before projecting it for an audience. Every splice should be looked at, first, to see that it is not out of frame in the ordinary manner by a fraction of a picture, and, second, to see that it is not out of frame for color by the connection of two light images or two dark images, instead of having a light and a dark image meet at the splice. Also, note where the title joins the picture which follows it, and study it to determine whether the second image, or second image-length of film, after the last title image, is a green-light image as it should be. Also look carefully for any broken sprocket holes or weak places in the film which might break during the run, bearing in mind that the Kinemacolor film gets a harder bumping and jerking than any simple black-and-white film, and that a weak place is likely to break in the run. Any of these troubles found should be corrected. Then every projection of the film should be watched for indications of a weakening film. The film is being subjected to harder service, and a more rigorous care, if possible, is necessary than with black-and-white working at only 50 feet per minute.

Oiling. The high-speed parts of the Kinemacolor projector should be oiled only with a good grade of sewing machine oil, and they should be oiled for every reel of film, that is, for continuous Kinemacolor projection, the rapidly moving parts of the motion head should be oiled every eight minutes. The high speed requires a thin oil, and a thin oil works out of the journals quickly and requires renewal.

For the journals which have the less rapid motion, a medium heavy machine oil may be used, such as is used for ordinary projection machines, oiling up at the beginning of the afternoon and again at the beginning of the evening run, or more frequently if the use of the machine is practically continuous.

The upper reel or feed reel requires special attention, because as the film nears its end the speed of revolution of that reel becomes pretty high. The fixed spindle of the feed magazine, over which the feed reel slips, should be lubricated with vaseline, and care should be taken to see that the reel turns freely on the spindle when the magazine door is closed.

Arc Lamp. With one window of the color shutter taking out all the green light and passing only the red light for the red-light images, and with the other window of the color shutter taking out all the red light and passing only the green light for the green-light images, it will be seen that a total of only half the light of the arc which passes through the film and the lens ever reaches the picture screen, the other half (sometimes the green half, sometimes the red half) never getting any farther than the color shutter.

To give an equal brightness upon the picture screen, compared with black-and-white pictures, the Kinemacolor film and color shutter require a much brighter arc. The resistance of the rheostat may be reduced, or two rheostats may be connected in multiple to give the additional current, together with carbons of a slightly larger diameter, say $\frac{3}{4}$-inch.

Lamp currents of 60, 75, and even 100 amperes have been suggested. The maximum current used must always be a compromise between screen brilliancy and condenser breakage.

Direction of Film Wind. The feed reel requires the film to be wound with the emulsion side "inside" when the reel is full, that is, the film is started with the emulsion side next the core when rewinding. The take-up reel turns "counterclockwise" and winds the film up with the emulsion side "outside," the film being started upon the take-up with the celluloid side next the core. While the feed reel might run in either direction, it is designed to run clockwise when feeding.

FRIESE-GREEN PROCESS

It may be said of the Friese-Green process of motion pictures in natural colors by colorphotography direct from nature that it is being developed in England. How nearly ready for the market the Friese-Green process is, cannot be said. Several very successful public exhibitions of the color projection achieved by the process have been given.

The Friese-Green process resembles the Urban-Smith process in that it produces the innumerable variations of color in nature by recording them in a few primary colors and then recombining them upon the picture screen by persistence of vision. The Friese-Green system of projection uses two projecting lenses, projecting two images of two colors upon the picture screen at the same time, shifting each one fourteen times per second, that is, at the regular speed of shifting ordinary black-and-white picture film. The negative is made through a color shutter of three colors. The colors really are orange, green, and violet, but are called red, green, and blue.

Process of Manufacture. The process of making is by the use of a double camera, as shown in Fig. 119, the camera being composed of two motographic mechanisms built into a single case, each mechanism using its own roll of sensitive film and its own intermittent shift mechanism, and having its own lens and its own color shutter. They are linked by being driven by the same crank shaft, and further by having one opaque shutter common to the two lenses. One of the lenses closes while the other opens, alternating until the picture is completed upon both reels of negative film, the alternate pictures being upon the two reels, respectively, when finished. In Fig. 119, the right hand of the operator turns the crank which drives the film mechanism, while the left hand is upon the panoram handle of the tripod head.

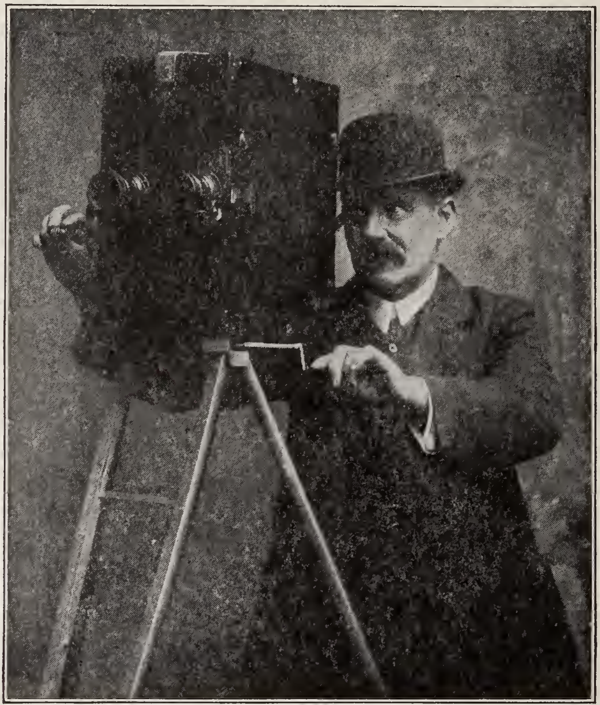

Fig. 119. The Friese-Green Color-Motography Camera in Operation

In addition to alternation in taking the negative images of the subject photographed, the two lenses take the image in a different color of light at each exposure. The color shutter, or color filter, changes for each exposure in each camera in the order of blue, green, red, blue, green, red, and so on, and as the two series of pictures are taken in alternation they are taken as follows:

(*1*) A green-light image with the left camera; (*2*) a blue-light image with the right camera; (*3*) a red-light image with the left camera; (*4*) a green-light image with the right camera; (*5*) a blue-light image with the left camera; (*6*) a red-light image with the right camera; (*7*) a green-light image with the left camera; and so on.

Projection of Film. In projecting, a similar color shutter of three colors is employed. A double motion head is used, with two arc lamps, two intermittent mechanisms, and two lenses, also two color shutters. The intermittent mechanisms and shutters are driven by the same crank handle, as are also the two color shutters.

A combination of simultaneous and alternative color projection is achieved by the two lenses and mechanisms of the Friese-Green projection head, as follows:

(*1*) The left lens projects a green-light image, and while the green light of the left lens is still upon the picture screen (*2*) the right lens projects a blue-light image upon it, thus giving the two colored images green and blue upon the picture screen at the same time; but the left lens now cuts off the green-light image and shifts its film and its color shutter, and (*3*) projects a red-light image upon the picture screen while the blue-light image of the right lens is still upon it, thus giving two images, blue and red, upon the picture screen at the same time; now the right lens cuts off the blue-light image and shifts its film and color shutter, and (*4*) projects a green-light image upon the screen while the red-light image of the left lens still continues, thus giving two images, red and green, upon the picture screen at the same time; again, while the green-light image from the right lens continues, the left lens shifts and (*5*) projects a blue-light image, thus giving two images, green and blue, upon the picture screen at the same time. This cycle of colors is repeated indefinitely or until the end of the scene. As the images are shifted for color, each image shows a progressive position of all of the objects in motion in the subject, so that motion as well as color is depicted.

The Friese-Green picture films when on reels of course come in pairs, and a pair of reels of 1,000 feet each will run upon the screen twenty minutes, each film running 50 feet per minute.

Splices. Splices, if made at all, require great skill and care. A break may be repaired sometimes by a patch without cutting out any of the film, but if any cut is to be made, it is necessary to cut three images from each of the two films, and in the same place, that unison between the two films of the pair may be maintained, and that synchronism between the images and the color shutters may be maintained.

Color Shutter. The color shutter of the Friese-Green camera and projecting machine is not the disk of the Urban-Smith device, but a transparent film band, endless, colored in sections with the three colors, and traveling with the film through the film gate of camera or projecting machine, respectively.

Care in threading up is necessary, with reference to the film pair, to get correspondence, and with reference to framing for color of the two color shutters or color bands.

Development of System. To show as far as possible the progress which has been made in the development of the Friese-Green system, and the time which has been consumed in the experiments, the following is quoted from an English magazine, *The Kinematograph Weekly*, of November 24, 1910:

> At Pendleton's Pictures, Co-operative Hall, Crewe, on Thursday last, Mr. Friese-Green gave a display of his system of natural color animated photography.
>
> The pictures were shown during the ordinary program, an announcement being made from the platform that a picture in color of Mr. Friese-Green's son signaling with colored flags, taken six years ago, and one as recently as two months ago, would be shown. These films, it was explained, were taken in the laboratory, and the commercial results of Mr. Friese-Green's labors would be submitted in about a month's time.
>
> In the six-year-old picture, three colors apparently were employed and the machine ran at ordinary speed. The results were crude, the picture was unsteady and fuzzy, and occasionally such colors as there were would disappear altogether.
>
> The two-year-old results were very much better. The subject was a revolving vase of flowers, but it was revolved so slowly as to be almost a *still* picture. There was a lack of true color in the blooms, but now and then a fine stereoscopic effect appeared.
>
> The last, and two-months-old picture was again an improvement, and

represented a colored-ware dessert dish containing fruits. The results obtained were curiously varied. Intermittently the color rendering would appear to be very good indeed, and the stereoscopic effects produced by the dish revolving would be very pronounced, giving a beautiful, soft, and natural appearance. The unsteadiness, however, was very great, and the defects, it must be confessed, were largely apparent.

It remains to be seen what Mr. Friese-Green can accomplish when he comes to do outdoor work; the films described above were the results, of course, of long exposures and slow rates of speed. Whether his methods infringe any of the master patents is a matter upon which we do not feel called upon to express an opinion. That question may be left with those directly interested. It is apparent from the above account of the results obtained that progress has been made, and we wish Mr. Friese-Green success in his continued efforts.

FILM MANUFACTURERS

The object of this list is to give to the reader some little knowledge of any manufacturer whose name or trademark he may see upon a film. The list does not pretend to be complete, not even for the manufacturers in the United States. In many instances, no information other than the home office address, or the American importer's name and address, is given. Possibly some of the manufacturers mentioned have discontinued the production of films, but so long as their films still are used in picture theaters, such data as is given concerning them will have an interest for that reason.

Adolpho Croce, Milan, Italy.

Ajax Film Company, A. J. Clapham, Managing Director, 12 East 15th Street, New York, N. Y.

"Ambrosio." Societa Anonima Ambrosio, Torino, Italy. Films imported into United States by New York Motion Picture Company, 1 Union Square, New York, N. Y., and sold through the Motion Picture Distributing & Sales Co.

Ambrosio Film Manufacturing Company, 16 Rue St. Marc, Paris, France. Films imported into United States by New York Motion Picture Company, 1 Union Square, New York, N. Y.

American Cinephone Company, 124 East 25th Street, New York, N. Y. Controlling patents for the Cinephone, a talking picture device, for the United States. Markets its product only through the American Kinograph Company.

American Film Manufacturing Company, A. M. Kennedy, General Manager, Bank Floor, Ashland Block, Chicago, Ill. Making picture film under the sign of the "Flying A." Sales through the M. P. Distributing & Sales Co.

American Kinograph Company, 124 East 25th Street, New York, N.Y., J. A. Toupin, Manager. Operating under the Cinephone patents. Supplies Cinephone sound records and picture film for the Cinephone Talking Pictures, also Cinephone talking machines for the Cinephone sound records.

American Motor Racing Picture Company, 330 East 35th Street, Chicago, Illinois. Irregular releases of special film pictures.

American Mutoscope and Biograph Company, New York, N. Y. Commonly called the "Biograph Company." Trademark, an "AB" monogram in a circle. Offices and studio in New York. Office address, 11 East 14th Street, New York, N. Y. Studio also in southern California Licensed under patents controlled by the Motion Picture Patents Company of America Film leased to licensed film exchanges only.

Animated Motion Picture Patents Company, New York, N. Y. A patent-holding company controlling a patent issued to Meredith Jones for a camera making a motion picture without stopping the film behind the lens.

Animatophone Syndicate, Ltd., 11 Denman Street, Piccadilly Circus, London, W., England. Talking and Singing Pictures.

Aquila Film Manufacturing Co., Torino, Italy.

Atlas Film Company, 10 East 15th Street, New York, N. Y. Films sold through the Distributing and Sales Company. Manufacturing picture films under the trademark of Atlas supporting the globe of the earth with a picture film encircling both athlete and globe.

Barker Motion Photography, Ltd., Topical House, 1 Soho Square, London, W. Sign of the Bulldog.

Bat Films. Lyons, France, 8 Rue du President Carnot.

Bavaria Film Manufacturing Company, Strassbourg.

"Biograph" Film, the American Mutoscope & Biograph Co.

"Bison" trademark, New York Motion Picture Manufacturing Co.

W. Butcher & Sons, Ltd., Camera House, Farringdon Avenue, London E. C., England. Making picture films under the trademark, "Empire."

Capitol Film Co., Washington, D. C., Sig. G. Bernstein, General Manager. Making picture films under the name of "Capitol Films," with the sign of the capitol dome in the letter "C."

Carlton Motion Picture Laboratories, 1 Union Square, New York, N. Y. Films sold only through the M. P. Distributing & Sales Co. Making picture films under the trademark "Reliance."

Champion Film Company, Mark M. Dintenfass, General Manager, 12 East 15th Street, New York, N. Y. Making picture film under the trademark "Champ" and the sign of the victorious gladiator. Sells through the M. P. Distributing & Sales Co.

"Chicken Film," Pathé Frères, sometimes so called because of the trademark, the sign of the red rooster.

E. G. Clement, 30 Rue du Petites-Ecuries, Paris, France.

Columbia Film Company, 301 West 27th Street, New York, N. Y. Sells only through the M. P. Distributing & Sales Co.

Continental Film Manufacturing Company, Copenhagen.

Cosmopolitan Film Company, Ltd., London, England.

Cricks & Martin, London, England. Makers of film pictures under the "Lion's Head" trademark.

Defender Films, Wm. H. Swanson, General Manager, 111 East 14th Street, New York. Sold only through the M. P. Distributing & Sales Co.

Ste. Drankoff, 12 Nicolaeiwich, Saint Petersburg, Russia.

Eclair Films, Paris, France, 8 Rue St. Augustin.

Edison Manufacturing Company, 65 Lakeside Avenue, Orange, New Jersey. Making picture films with the trademark of the "Circle E." Licensed by the Motion Picture Patents Company of America, which controls the Edison patents. Films are leased to licensed film exchanges only.

Essanay Film Manufacturing Company, 435 North Clark Street, Chicago, Ill. Studios in Chicago and Colorado. Licensed under the patents controlled by the Motion Picture Patents Company of America. Leases film to licensed film exchanges only. Trademark, the Indian head.

Film d'Art Film Manufacturing Company, Paris, France.

The Gaumont Company, Paris, France. Office, 57 Rue St. Roch. Usines et Theater, 12 Rue de Alouettes, Paris. American office, 125 East 23rd Street, New York. Films imported into United States by George Kleine, Chicago, Ill.

Gnome Motion Picture Company, offices and studios at southwest corner of Park and Tremont Avenues, Bronx, New York, N. Y. Licensed under patents of the Animated Picture Patents Company.

Great Northern Film Company. Home office, "Nordisk Film Company, Copenhagen." American office, 7 East 14th Street, New York, N. Y. Trademark of the Polar Bear on the Earth Globe.

Hepworth Manufacturing Company, London, England, making picture films under the trademarks of "Hepworth" and "Hepwix."

Hispano Films, Barcelona, Spain, Craywinckel, 20 San Gervasio.

David Horsley, German Savings Bank Building, 4th Avenue and 14th Street, New York, N. Y. Making picture films under the trademark of "Nestor." Sold through the M. P. Distributing & Sales Co.

"Imp" trademark, Independent Motion Picture Co.

Independent Moving Picture Company of America, 102 West 101st Street, New York, N. Y. Carl Laemmle, President. Manufacturing picture films under the trade name "IMP" and the trademark of an imp associated with a shield design bearing the letters "IMP." Films sold through the Motion Picture Distributing and Sales Company.

Itala Film Manufacturing Company, Torino, Italy. Films imported into United States by New York Motion Picture Company, 1 Union Square, New York, N. Y.

Kalem Film Manufacturing Co., New York, N. Y. Making picture films under the name "Kalem" and the sign of the blazing sun with the word "Kalem." Licensed by the Motion Picture Patents Company of America. Films leased to licensed film exchanges only.

Kinemacolor Company of America, Allentown, Pa. Making Kinemacolor picture films and manufacturing Kinemacolor projecting machine. Kinemacolor is a process of motion pictures in natural colors by color photography direct from nature.

"Kineto" Films. Kineto, Ltd., 48 Rupert Street, Shaftsbury Avenue, London, W., England.

George Kleine, 52 State Street, Chicago, Ill. Imports "Gaumont" and "Urban-Eclipse" films into America under license of the Motion Picture Patents Company of America. Films are leased to licensed exchanges only.

"Latium" Film, Manifattura Cinematografica Italiana.

"Le Lion" Cinematographes Company, 15 Rue Grange-Bateliere, Paris, France. Manufacturing films under the trademark of the lion rampant mauling a roll of film.

"Lion's Head" Film, Cricks & Martin, London, England.

Lubin Manufacturing Company, Philadelphia, Pa. Making picture film under the trademark of the Liberty Bell. Licensed under the patents controlled by the Motion Picture Patents Company of America. Leases film to licensed film exchanges only.

Lux Film Manufacturing Company, Rue Louis-le-Grand, Paris, France.

Manifattura Cinematografica Italia, 77 Via Appia Nouva, Rome, Italy. Making picture films under the trademark, "Latium Film."

G. Melies, New York, N. Y. Making picture films under the trademark of the "Star." Licensed by the Motion Picture Patents Company of America. Films leased to licensed film exchanges only.

Motion Picture Distributing and Sales Company, 111 East 14th Street, New York, N. Y. Act as selling agents for a number of American and Foreign manufacturers. Handle Éclair, Imp, Yankee, Bison, Powers, Thanhouser, Ambrosio, Atlas, Champion, Nestor, Itala, Defender, Lux, Cines, Solax, Great Northern, Columbia, Capitol and Reliance films for the United States.

Motion Picture Patents Company of America, 10 Fifth Avenue, New York, N. Y. A company organized to control the Edison, Biograph, Armat, and Vitagraph patents pertaining to the motion picture industry. Some of these patents are the following: Reissue 12,192; 578,185; 580,749; 586,953; 588,916; 673,329; 673,992; 707,934; 722,382; 744,251; 770,937; 771,280; 785,205 and 785,237. The following companies are licensed by the M. P. Patents Company to manufacture picture film under the above listed patents: The *American Mutoscope and Biograph Company* of New York City; the *Edison Manufacturing Company* of Orange, New Jersey; the *Essanay Company* of Chicago; the *Kalem Company* of New York City; *Lubin Manufacturing Company* of Philadelphia; *Pathé Frères* of Bound Brook, New Jersey; the *Selig Polyscope Company* of Chicago; the *Vitagraph Company of America* of New York City; and *G. Melies* of New York City. In addition, *Pathé Frères* are licensed to import from their factories in France, and *George Kleine* of Chicago is licensed to import "Gaumont" and "Urban-Eclipse" films. This makes a total of ten licensees of the Motion Picture Patents Company. The output of each of the licensees is limited by the terms of its license. All films manufactured or imported under the licenses of the Motion Picture Patents Company are not sold, but remain the property of the manufacturer or importer, being leased to licensed film exchanges only for a term of months, during which time the licensed film exchange rents the films to exhibitors, and at the end of which time the exchange returns the film to the manufacturer or importer to be destroyed. By this means, only the latest films may be obtained from the licensed film exchanges. The object is to cause the withdrawal from theater exhibition of films which have had a reasonable amount of wear, and to maintain as high a standard as possible in the film theaters both for lateness of titles and freedom from wear of the films.

National Film Manufacturing & Leasing Co., 12 East Fifteenth Street, New York City. A manufacturing and leasing company operating independently of the Motion Picture Patents Company of America, and independently of the Motion Picture Distributing and Sales Company.

Navone Film, Torino, Italy.

"Nestor" Films, made by David Horsley, German Savings Bank Building, 4th Avenue and 14th Street, New York, N. Y.

New York Motion Picture Company. Offices and Studio in New York City. Office address, Lincoln Building, 1 Union Square, New York, N. Y. Making picture film under the trademark of "Bison" and the sign of a buffalo rampant. Sells film only through the M. P. Distributing & Sales Co. Importing agents for the United States for "Ambrosio" and "Itala" films.

Paragon Bioscope Company, Ltd., 13 Cecil Court, Charing Cross Road, London, W. C.

Pathé Frères. Trademark of the Red Rooster. Home office, 14 Rue Favart, Paris, France. American offices in New York, Chicago and San Francisco. Two studios in France and an American studio and factory at Bound Brook, New Jersey. Produce American and foreign subjects, importing many foreign subjects into America. Leaders in so-called "hand colored" pictures, colored by stains in an imitation of the colors of nature, the colors being applied to the film by machinery. American factory and American importations of foreign films licensed under patents controlled by the Motion Picture Patents Company of America. Films leased to licensed film exchanges only.

The Powers Company, 241st Street and Richardson Avenue, New York, N. Y. Making picture films under the trademark of "Powers Picture Plays." Sales through the M. P. Distributing & Sales Co. This company takes its name from "Pat Powers," and should not be confused with the Nicholas Power Company, which makes the Cameragraph projecting machines and does not make film.

"Reliance" trademark, Carlton Motion Picture Laboratories.

Revier Motion Picture Company, H. Revier, President, Majestic Theater Building, Salt Lake City, Utah. The trademark is a picture of a temple with the word "Revier."

Selig Polyscope Company, Chicago, Illinois. Offices at Dearborn and Randolph Streets. Studio and factory at North Western Avenue and Irving Park Boulevard. Making picture film under the sign of the "Diamond S." Licensed by the Motion Picture Patents Company of America. Leases film to licensed film exchanges only.

Sicania Film Factory, 45 Piazzi Giuseppe Verdi, Palermo, Italy. The trademark "Sicania."

Societe Cines. Making films with the trademark of the Wolf-and-Babes. Office address, 11 Rue Saint Augustin, Paris, France. Studios in France and in Italy.

Solax Company, 147 Fourth Avenue, New York, N. Y., factory and studio at Flushing, Long Island. Making picture film under the name "Solax." Sold only through the M. P. Distributing & Sales Co.

Sunny South Film Company, Rhodes Building, Atlanta, Ga.

Thanhouser Company, manufacturing with the trademark "TCO." Offices and studio at New Rochelle, N. Y. Films sold through the Distributing and Sales Company.

Tyler Film Company, Ltd., London, England, makers of film pictures under the trademark, "T. F. C."

Unitas Film Manufacturing Company, Torino, Italy.

Charles Urban Trading Company, film publishers, Urbanora House, 89 Wardour Street, London, W., England. "Urban" and "Urban-Eclipse" black-and-white films and "Urban-Smith" Kinemacolor films.

The Vitagraph Company of America, 116 Nassau Street, New York, N. Y. Studio on Long Island. Licensed under the patents controlled by the Motion Picture Patents Company of America. Film leased to licensed film exchanges only. Trademark, the letter "V" surmounted by an eagle with spreading wings.

Warwick Trading Company, Ltd., 113 Charing Cross Road, London, W. C., England.

"Wrench" Films, 50 Gray's Inn Road, London, W. C., England.

Yankee Film Company, 344 East 32nd Street, New York, N. Y. Making picture film under the trade name of "Uncle Sam Films" and the sign of Uncle Sam in costume holding a white "Y." Films sold through the M. P. Distributing & Sales Co.

SCENE FROM "A TRIP THROUGH SCOTLAND"
A Striking Example of Modern Travelogue Material
Courtesy of the *Kleine Optical Co., Chicago*

REVIEW QUESTIONS

REVIEW QUESTIONS

ON THE SUBJECT OF

THE OPTICAL LANTERN

---

1. What is the optical lantern?

2. Name the parts which go to make up the complete optical lantern.

3. Why is the slide put in the carrier head down?

4. Give the rule for putting the slide in the lantern so it will show properly upon the screen.

5. What is a *thumb spot* and for what purpose is it used?

6. What is the purpose of the condenser?

7. Describe the *lime light.*

8. Describe the position of the carbons when set for a direct-current motion-picture arc.

9. Describe the position of the carbons when set for an alternating-current motion-picture arc.

10. Give the rule for centering the lamp upon the motion-picture screen.

11. With one condenser broken and only one condenser left, should the latter be placed in the front or the back position in the condenser frame?

12. Describe the slide carrier.

13. What is the principle of the slip-slide carrier?

14. Describe the dissolving lantern.

15. How are two shutters for a double dissolving lantern set to close the lenses?

16. Describe the operation of projecting the slides for a song when using the double lantern.

17. When should the projection operator use a quick change in dissolving? When use a slow change?

18. Describe the use of two rheostats for one lamp in motion-picture projection and fixed slide projection from the same lamp.

19. How is the table used in order to find the size of a picture when the lens focal length and the length of throw are given?

20. How would you find the size of a picture by arithmetic if you have not the table handy?

21. Give one of the remedies for the keystone-shaped picture.

22. How would you repair a slide which has a cracked cover glass?

23. How would you make quickly an emergency announcement slide?

REVIEW QUESTIONS

ON THE SUBJECT OF

MOTION HEAD

PART I

---

1. In what way is motion seen or detected in a motion-picture film?

2. Name more than one form of motion-picture record.

3. Name more than one way of viewing a motion picture.

4. At what speed are ordinary motion pictures taken?

5. In what way is persistence of vision taken to advantage in projecting a motion picture?

6. What is the ordinary speed of projection of a motion picture, in number of pictures per second? In feet of film per minute? In minutes for a reel of 1,000 feet of film?

7. What are the differences between the optical systems or light handling systems of the still-slide projection and the motion-picture projection?

8. With two condenser glasses of different thicknesses to put into the condenser case for the lantern, which glass is to be put next to the lamp, the thick one or the thin one?

9. If the middle of the motion head were 14 inches from the middle of the condenser case, thus making the exact theoretical length of condenser glasses 14 inches and 5 inches, what focal length should be chosen for the lamp to make the lamp easy to work?

10. Find the lens length required for the theater, assuming that you are in the theater and can make measurements needed.

11. What is meant by "a pair of matched lenses for motion head and stereo?"

12. Describe the action of the *multiple shutter*.

13. Give the universal rule for setting any motion-head shutter.

14. What is the purpose of the fire shutter or safety shutter of the motion head?

15. How is a set of film-gate tension springs adjusted?

16. Name more than one kind of intermittent movement.

17. Describe briefly a Geneva intermittent mechanism.

18. Describe briefly a pin or claw intermittent mechanism.

19. Describe briefly a beater intermittent mechanism.

20. What is meant by *duplex projection?*

21. What are the upper and the lower feed loops?

22. What is the reason for using the feed loops?

23. Name the essential elements for moving the picture film through the motion head, beginning with the feed reel and progressing in order through to the take-up reel.

24. What is meant by the term *framing?*

25. How is a broken film spliced?

26. What are leaders and tails, and of what use are they?

REVIEW QUESTIONS

ON THE SUBJECT OF

MOTION HEAD

PART II

---

1. In what way do different projecting machines vary from each other, in general?

2. Name some of those parts which are found in all projecting machines, but merely differ in form on the various machines.

3. How is the Edison friction take-up adjusted?

4. What adjustment of the Edison friction take-up is required while rewinding?

5. In what way is the take-up device tightened or loosened on the Motiograph?

6. Describe the Motiograph safety shutter.

7. How is the framing accomplished in the Power's No. 5 Cameragraph?

8. Describe the principle of operation of one of the Cameragraph safety shutters, either Style A or Style B.

9. Describe the Power's No. 6 pin-cross intermittent movement.

10. In what feature is the Pathé machine different from all others, regarding its manufacture?

11. How many amperes are recommended for the arc lamp in the Pathé machine?

12. Describe the Pathé shutter.

13. Describe the "Standard" or "American" method of protecting the motion-picture film from fire.

14. What is the difference between "flicker" and "jiggle?"

15. What is the principle of operation of the "Automatic Rewinding" Standard projector?

16. In the old style of Selig Polyscope, what type of intermittent mechanism was used?

17. In the new style of Selig Polyscope, what type of intermittent mechanism is used?

18. What is the distinctive feature of the Edengraph film path?

19. How is the Edengraph film gate hinged?

20. Describe the manipulation of the control knobs in the Edengraph lamp.

REVIEW QUESTIONS

ON THE SUBJECT OF

MOTION HEAD

PART III

---

1. In what way does the talking picture differ from the silent motion picture?

2. What is the greatest difficulty which the manufacturer will find in attempting to make picture films and sound records for talking pictures?

3. What is meant by *synchronism*?

4. What are the classes of subjects to which "talking pictures" are limited because of the limitations of the sound-reproducing machines?

5. Under what conditions may records of both picture and sound be reproduced from one machine?

6. What prevents doing this in a large theater?

7. In what two phases must the manufacturer consider the feature of synchronism?

8. Name the three classes of talking-picture projecting machines, according to the means for keeping the pictures and sounds in synchronism.

9. Describe one machine of each class.

10. When for any reason the sound and picture records must be brought together while running, which speed is changed to make up the difference, and why?

11. What is the method of manufacture in small talking subjects?

12. What is the method of manufacture in large talking subjects?

13. How is color projected from a Kinemacolor (Urban-Smith) film?

14. How fast are the Kinemacolor pictures projected by the motion head?

15. In what way does alternate color projection in Kinemacolor use the persistence of vision?

16. What type of intermittent mechanism does the Kinemacolor projector use?

17. How is the Kinemacolor color shutter of the projector adjusted?

18. How does Kinemacolor framing differ from ordinary black-and-white framing?

19. In what color is the Kinemacolor title framed?

20. What care is required in splicing a Kinemacolor film?

21. In what detail does the Friese-Green color process differ from the Urban-Smith or Kinemacolor?

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